



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

FORESTRY

SD

11

S7

A3

NO. (D-1)

BUHR - B



a39015 00018552 3b

SD

11

57

A 3

1110-11

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF SOILS.

THE MECHANICS OF SOIL MOISTURE.

BY

LYMAN J. BRIGGS,
PHYSICIST, DIVISION OF SOILS.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1897.

 LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., September 1, 1897.

SIR: I have the honor to transmit herewith a paper upon the Mechanics of Soil Moisture, prepared by Mr. Lyman J. Briggs, physicist of this Division. The subject is necessarily treated in a technical way in order that it may be clearly understood by the student of agricultural science. It explains, however, more fully and clearly than ever before the actual cause of the capillary movement of water in soils and gives a much clearer knowledge of the laws and principles governing that movement than we have ever possessed. This is a subject of vast practical importance to the agriculturist, for the relation of his soils to water largely determines the class of crops which can be successfully grown upon them.

This paper is a valuable contribution to science, and I recommend that it be published as Bulletin No. 10 of this Division.

Respectfully,

MILTON WHITNEY,
Chief of Division.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction.....	5
Properties of water affecting its retention and movement in the soil.....	6
Gravitation of water.....	6
Surface tension.....	7
Viscosity.....	10
Hygroscopic state.....	11
Properties of films.....	13
Pressure of a film.....	14
Surface of no pressure.....	15
Form of water surface between two soil grains.....	18
Establishment of equilibrium between two unequal masses of capillary water.....	19
Salts as affecting the movement of water in soils.....	20
Temperature as affecting the movement of water in soils.....	21
Influence of texture and structure of soils on the acquirement and retention of soil moisture.....	21
Displacement of capillary water through gravitation.....	22

ILLUSTRATIONS.

Fig. 1. Condition of equilibrium among the surface tensions of three media in contact.....	9
2. Pressure of a film.....	15
3. Forms of the catenary.....	16
4. Catenoidal film.....	17
5. Cylindrical film.....	17
6. Adjustment of water between two capillary spaces.....	19
7. Displacement of capillary water through gravitation.....	23

THE MECHANICS OF SOIL MOISTURE.

INTRODUCTION.

It is intended in this bulletin to present the application of certain dynamical principles to the problems attending the movement and retention of soil moisture. Among these problems may be mentioned the capacity of a soil for water, the adjustment of water between a dry and a wet soil, the relation of texture, structure, and temperature to the water capacity, and the effect of fertilizers upon the water content of a soil.

The extreme complexity of the texture and structure of soils renders very difficult any rigorous analysis of the phenomena connected with the movement of soil moisture. There are, however, two conceptions of the soil which have been productive of good results. One is to consider the soil as made up of very fine particles without regard to the form of the particles or capillary spaces, the only condition being that the interstitial spaces are so small that the amount of interstitial space represented on any small section taken in any direction through the soil should be practically constant. Such a structure has been assumed by Dr. Katao¹ as the basis of an extensive memoir on the movement of water in soils. In the other conception of the soil the particles are assumed to be of some simple geometrical form, such as the sphere. By means of different arrangements of these spherical particles, structures having different amounts of interstitial space may be obtained. A calculation of the interstitial space for several arrangements has been given by Soyka,² and a comparison with the structure of typical soils was made later by Professor Whitney.³

While the principles that will be developed here are independent of the structure of the soil, the various arrangements of the soil grains which are set forth in the last form of structure referred to will be used to illustrate the principles and forces involved.

¹Ueber die Wasserbewegung in Boden. Bul. of College of Agriculture, Imperial University of Japan, vol. 3, No. 1, 1897.

²Forschungen auf dem Gebiete der Agrikultur-physik, B. 8, S. 1, 1885.

³Agricultural Science, vol. 3, p. 199, 1889.

PROPERTIES OF WATER AFFECTING ITS RETENTION AND MOVEMENT IN THE SOIL.

The water contained in a soil may be considered to be of three kinds—gravitation water, capillary water, and hygroscopic water. Gravitation water is that portion which is in excess of the amount which the soil is able to retain under existing conditions, and is consequently free to drain away. The capillary water is that part which would be retained in the capillary spaces under these conditions, and which is capable of movement through capillary action. The hygroscopic water is that found on the surface of the grains, which is not capable of movement through the action of gravity or capillary forces.

The maximum amount of water which a given soil may contain depends upon the resultant effect of the two forces—gravitation and surface tension. The force due to gravity is proportional to the mass of the liquid considered, and is always directed vertically downward. In other words, it is the weight of the liquid. This mass of liquid would therefore leave the soil if not opposed by the action of some other force, the vertical component of which acting along the same line as the force of gravity must be equal to it and opposite in direction. The effective part of this force and the manner of its application, which is of the greatest importance in determining the movement of water in a soil, will be considered later.

GRAVITATION OF WATER.

When a column of soil is saturated with water, its lower end being left in such a manner that water can escape, a gradual draining of the soil takes place. The rate of flow of this water gradually becomes less and less until finally it ceases. The amount of water which thus leaves the soil under the action of the force of gravity would be gravitation water, while that remaining in the capillary spaces of the soil would be capillary water.

There is no sharply-drawn line between these two quantities of water. The relative proportion depends, among other factors, upon the texture and structure of the soil, the surface tension of the soil water, the temperature, and the length of the column of soil considered. The importance of this last factor can be shown from the following considerations: Suppose we have 100 cubic inches of soil packed into 100 cubical boxes without bottom or top, each containing 1 cubic inch. Suppose the soil in each box to be saturated with water. There will be a free water surface at the top and at the bottom of each box. By means of forces existing in these surfaces the water in each cube is enabled to overcome the attraction of gravity, so that each cube is able to retain an amount of water equal to that necessary to produce saturation. In this case, therefore, there is no gravitation water. Suppose now that these cubical boxes are built up in a vertical column 100 inches high. The water surfaces previously existing at the top and bottom, respec-

tively, of two cubes now disappear when one cube is placed on top of the other. Instead of having 200 surfaces as before, we now have only two surfaces, and they are called upon to support a column of water one hundred times as high as before. This they are unable to do, and water begins to drip from the lower surface. This water, which was previously what we have termed capillary, now becomes gravitational in its nature, due simply to a change in the length of the column. If the water in the soil was held in vertical capillary tubes running throughout the length of the column the water in each tube would simply fall until the two surfaces were able to support the weight of the liquid. In the soil, however, we have a different condition. As the water begins to leave the upper part of the column new surfaces are developed *within* the soil. As the water continues to drain away, these surfaces become more efficient in a way which will be explained later, and finally there comes a time when the opposing force exerted by these surfaces is sufficient to balance the weight of the liquid and the drainage ceases.

As an example of the displacement of water toward the bottom of a vertical column of soil, it is of interest to consider some experiments by Professor King,¹ who showed that for coarse sands this displacement is very marked. A vertical tube, 42 inches in length, filled with sand, continued to discharge water at its lower end for forty days after saturation. At the end of that period the top 6 inches of soil contained but 2 per cent of water, while the bottom 6 inches averaged 18 per cent. These results were in a general way corroborated by actual field observations on an area protected from precipitation and evaporation. No experiments were made on soils of a finer texture. It will be shown later that in such soils the movement would probably be much less marked.

SURFACE TENSION.

It has been pointed out that the force exerted on a liquid through gravity varies only with the mass of the liquid. This force can therefore change in value only when the mass of the liquid varies. From this it follows that any movement of water which takes place after equilibrium has been once established must be brought about through a change in the amount of water present in the soil or through a change in the force opposing gravitation. It is therefore of importance to consider the nature of this opposing force which we call surface tension.

The phenomenon of surface tension is due to the existence of molecular forces. In a suspended drop of water, for example, the particles in the interior of the liquid are attracted equally in all directions by the other particles of the liquid. The resultant attraction on any particle in the interior is therefore zero, and it is free to move through the liquid. A particle on the surface of the drop, on the contrary, is not attracted equally on all sides, since the molecules of the gas surround-

¹ Fluctuations in the Level and Rate of Movement of Ground Water. F. H. King, U. S. Dept. of Agriculture Bul. No. 5, Weather Bureau, p. 25.

ing the drop exert less attraction upon the particle than is exerted by the particles of the liquid. The resultant attraction is therefore inward, along a line perpendicular to the surface of the liquid at that point. Now, the equations representing the behavior of the drop under the action of these forces are identical with those obtained if we imagine the drop inclosed in a water-tight membrane having a uniform tension. The action of the drop is therefore the same as if this imaginary membrane actually existed, and what we call surface tension is the tension that this ideal membrane would have to possess in order to produce the observed phenomena. This ideal membrane differs from all material membranes in that its tension does not change when the surface is increased. When the surface is extended, particles which were formerly in the interior are brought to the surface, so that the number of particles per unit of area of the surface always remains the same. The surface tension is also practically independent of the form of the surface. The mathematical theory indicates a very slight increase where the mean curvature is concave, and a slight decrease where it is convex. This difference is too small to be verified experimentally, but is of interest in connection with the fact that evaporation will take place from the convex surface at the same time that condensation is taking place on the concave surface. This in itself, then, must furnish a means of gradual adjustment of the water in the capillary spaces of a soil.

It is of importance here to distinguish clearly between surface tension and the effective force of a film. It has just been stated that the surface tension or the energy per unit area in the film is independent of the form and extent of the surface. The effective force or the pressure of the film, on the other hand, is dependent upon both the form and extent of the surface as well as upon the surface tension. This subject will be discussed more fully later.

When a drop of a liquid is placed upon the horizontal surface of a solid, it either rapidly spreads out upon the surface in a thin film, as a drop of water on a clean glass plate, or else remains in the form of a drop, with as little surface as possible in contact with the solid, as in the case of mercury on glass. If we know the surface tensions of the three surfaces which separate the solid and liquid, solid and gas, and liquid and gas, respectively, the action of the drop can be anticipated. This arises from the following considerations: Let the solid, liquid, and gaseous media in contact be represented by s , l , and g , respectively. The surfaces separating these three media will meet in a line. Through any point in this line pass a plane perpendicular to the line, and let this section be represented by the plane of the paper in fig. 1.

At the point O there exist three forces equal in magnitude to the tensions of the surfaces of separation and directed along lines tangent to the surfaces at that point. In order that the system may be in equilibrium it is necessary that each of these forces shall exactly balance the resultant force of the other two. Let the vectors in the

figure represent the direction and magnitude of these three forces. If these forces are in equilibrium, then lines drawn parallel to the vectors and equal to them in length will form the three sides of a triangle. The exterior angles of this triangle represent the angles between the surfaces of separation of the three substances.

If a system is not in equilibrium, an adjustment must take place through change in the *direction* of the vectors, since their magnitude remains constant. Consequently, the surfaces tend to change until the necessary angle is obtained. In general, if the tension of the solid-liquid surface is greater than the sum of the tensions of the other surfaces, the liquid will gather itself up in a drop, as in the case of

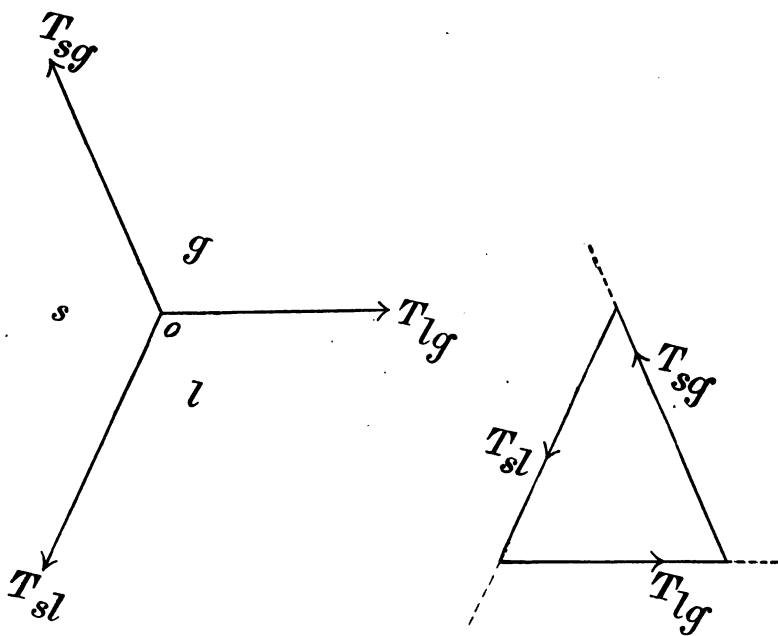


FIG. 1.—Condition of equilibrium among the surface tensions of three media in contact.

mercury. If, however, the solid-gas surface has a tension greater than the resultant of the other two, the liquid tends to spread out over the surface of the solid. If the tension of the liquid-gas surface is greater than the difference between the tensions of the liquid-solid and the gas-solid, then the liquid finally reaches a condition of equilibrium. The angle between the liquid-solid and the liquid-gas surfaces is known as the capillary angle.

In the case of oil on water the tension of the water-air surface is greater than the sum of the other two tensions, so that no triangle of forces can be formed. The system is therefore unstable and the oil spreads out on the water indefinitely in a film until it ceases to have the same physical properties as the liquid. Lord Rayleigh has made

use of the minimum thickness of this film as the basis of an estimation of the maximum diameter of oil molecules.

With the exception of mercury, water possesses a higher surface tension than any other substance which is liquid at ordinary temperatures. The surface tension of water¹ expressed in dynes per centimeter is 75.6 at 0° C. and 72.1 at 25°. The temperature coefficient is thus about -0.14 dynes per degree Centigrade. The surface tension of most aqueous solutions of salt is higher than that of water, and the surface tension increases with the concentration of the solution, as is shown in the following table:

Surface tension of solutions of salts in water.

Salt in solution.	Density.	Concentration. ^a	Temperature.	Surface tension.
			° C.	Dynes per cm.
KCl.....	1.170	25	15-16	82.8
KCl.....	1.101	15	15-16	80.1
KCl.....	1.046	7	15-16	78.2
NaCl.....	1.193	25	20	85.8
NaCl.....	1.107	15	20	80.5
NaCl.....	1.036	5	20	77.6
K ₂ CO ₃	1.357	35	15-16	90.9
K ₂ CO ₃	1.157	16	15-16	81.8
K ₂ CO ₃	1.040	5	15-16	77.5
KNO ₃	1.126	19	14	78.9
KNO ₃	1.047	7	14	77.6
MgSO ₄	1.274	24	15-16	83.2
MgSO ₄	1.068	6	15-16	77.8

^a Approximate weight of the dissolved substance in 100 parts by weight of the solution.

Most organic substances found in soils, especially those of an oily nature, being insoluble in water and hence most evident on the surface, lower the surface tension to a marked degree. The tension of soil extracts, therefore, is generally much lower than that of pure water, in spite of the presence of dissolved salts.

VISCOSITY.

It has been pointed out that the two great factors in determining the movement and retention of soil moisture are gravitation and surface tension. We have now to consider a modifying influence which is exerted upon these factors through the viscosity, or internal friction, of the liquid upon which these forces are acting, the effect of which is to retard the establishment of equilibrium. The relative viscosity of fluids may be determined by their rate of flow through capillary tubes under uniform conditions. Viscosity is generally expressed in terms of the coefficient of viscosity, which is numerically equal to the force necessary to maintain a flow of a layer of unit area past another layer of unit area with unit relative velocity. This coefficient is influenced by temperature to a considerable extent. If we take the viscosity² of water at 0° C.

¹ Smithsonian Physical Tables, 1896, p. 128. These values are a mean of the results obtained by Lord Rayleigh from the wave length of ripples (Phil. Mag., 1890), and by Hall from the direct measurement of the tension of a flat film (Phil. Mag., 1893).

² Smithsonian Physical Tables, 1896, p. 136.

to be 100, the viscosity at 25° C. is 50, at 30° is 45, and at 50° about 31. This great variation in viscosity with change of temperature is illustrated in the flow of water through soils, which King¹ found in his leaching experiments but failed to explain. He observed the rate of flow at 9° C. to be 6.15 grams per minute, while the rate of flow at 32.5° C. was 10.54 grams per minute. The ratio of the two rates of flow is 1.71. Now the viscosity of water at 9° C. as compared with water at 0° C. is 75.6, and 32.5° is 42.5. The ratio of the two viscosities is 1.77, which agrees very well with the ratio of the observed rates of flow.

The viscosity of gases in opposition to that of fluids increases with increase of temperature. Air, which is largely used in making so-called "permeability" determinations of soils, has a viscosity of 0.00017 ($1+.00273 t$). An increase in temperature of 40° C. would therefore cause the coefficient of viscosity of air to increase one-tenth of its amount. This evidently should always be taken into consideration in determining the physical character of a soil. G. Ammon,² in using air to determine the relative permeability of soils, and neglecting the change in viscosity with temperature, found that the permeability of a soil decreased with increase of temperature. The rate of flow of air at the higher temperatures as observed by him, when corrected for viscosity, agrees with the flow observed for the lowest temperatures within the errors of experiment.

HYGROSCOPIC STATE.

Most solid substances when exposed to ordinary atmospheric conditions condense upon their surfaces a slight amount of moisture. This moisture adheres with remarkable tenacity, and can be completely driven off only by prolonged heating at temperatures above the boiling point of water. In some soils the presence of hygroscopic moisture is very marked, on account of the large amount of surface presented by the soil grains. Air-dried samples, in which all visible evidences of moisture have disappeared, still contain under ordinary atmospheric conditions moisture in the hygroscopic form, amounting in some soils to 8 to 10 per cent of the dry weight.

The table following, taken from a paper by Loughridge,³ illustrates the variation of hygroscopic moisture in soils of different texture. These values were obtained by exposing the soil in a very thin layer to a saturated atmosphere, kept at a constant temperature, for a period of twenty-four hours.

¹U. S. Weather Bureau Bul. No. 5, 1892, p. 66.

²Forschungen auf dem Gebiete der Agrikultur-Physik, B. 3, S. 209.

³Investigations in Soil Physics.—R. H. Loughridge. Report of the California Experiment Station, 1892-93, p. 70.

Hygroscopic moisture of soils.

Name and character.	Hygroscopic moisture.	Mechanical analysis.		Chemical analysis.	
		Clay.	Clay to 0.25 mm.	Soluble silicates.	Ferric hydrate.
Clay:		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Black adobe	14.5	32.6	74.0	23.3	7.7
Red soil	14.2	24.8	57.1	54.0	9.5
Red mountain soil	13.7	52.2	67.9	26.9	29.7
Red volcanic soil	11.1	29.8	61.2	34.3	12.0
Alluvial soil	10.3	31.5	76.8	20.7	9.1
Alkali soil	2.6	26.1	54.0		
Loams:					
Sediment soil	9.2	12.1	55.6	25.1	7.3
Granitic soil	5.9	11.9	32.8	21.0	6.2
Plains soil	4.9	10.5	34.9	16.5	6.6
Sandy:					
Gila bottom soils	3.5	3.2	8.7	8.9	7.4
Sandy soil	1.2	2.6	8.9		
Do	.8	2.8	5.2		

Under the conditions employed in the determinations given in the table it is not improbable that water was condensed in some of the more minute capillary spaces. Lord Kelvin¹ has shown that such a minute capillary surface is capable of condensing moisture even when evaporation is taking place from a neighboring plane surface of water. Some capillary spaces might therefore be able to hold minute quantities of water under conditions which would remove the water from larger spaces. In this way we might have some water held in a soil by capillary action, under conditions which would seem to indicate that the water content must be purely hygroscopic in its nature.

The nature of this thin film which constitutes the hygroscopic moisture is not definitely known. It may extend uniformly over the surface of the grains independently of their form or nature; or it may be discontinuous, occurring only in spots on the surface and depending to some extent on the form and nature of the grain. It would seem justifiable to assume that the amount of moisture thus held is proportional to the surface of the grains, but this conclusion is supported only in a very general way by the results given in the investigation quoted, from which the above table was compiled. Loughbridge remarks, in explanation of this, that the clays may be considered as very complex substances made up not only of particles in a very fine state of division, but combined with ferric, aluminic, silicic, and humic hydrates existing in the soil in greatly varied amounts. Even if the presence of these hydrates did not directly influence the hygroscopic water of a soil their decomposition at the high temperature which it is necessary to maintain in order to drive off the hygroscopic moisture would introduce a disturbing factor in the value of the hygroscopic water content. On the other hand, it must be remembered that a mechanical analysis of a soil gives only in a very general way an idea of the surface area of the grains in a soil, and that a soil exposed to a saturated atmosphere is apt to acquire considerable moisture which is not strictly hygroscopic. The

¹ Maxwell, Theory of Heat, p. 287.

relation of hygroscopic moisture to the relative surface area presented by different soils, determined by a method which depends directly upon the amount of surface, will be made the subject of a later investigation.

PROPERTIES OF FILMS.

Since the movement and adjustment of water among the soil grains depend upon forces whose action is the same as if a uniform tension existed in the water surfaces, it is very important to study the properties of these surfaces and their effectiveness under different conditions. Water is not a convenient substance to use in the experimental study of films, since its high surface tension and low superficial viscosity make the film unstable, except when very small surfaces are used. An ordinary soap solution, on the other hand—or better, a solution of oleate of soda to which a quantity of glycerin has been added—gives films of great stability and highly adapted to experiment.¹

The most familiar form of a soap film is the spherical surface assumed by a bubble, as representing the least surface area under the given conditions. The fact that the bubble will contract and finally become a plane film across the end of the pipe shows that there is a tension in the film which produces a pressure upon the air inside the bubble. Suppose, now, that a large and a small bubble are connected by means of a short pipe of circular cross section. It might be expected that the large bubble would blow the smaller one out until the two were of equal size. On the contrary, the opposite takes place. The small bubble contracts until it becomes a film across the end of the pipe. This film, however, is not a plane as in the first case, since on one side there is the pressure due to the large bubble and on the other the atmospheric pressure. It will consequently assume a spherical surface identical with a segment of the large bubble, of which it in reality forms a part, separated from it by means of the pipe.

The action of the smaller bubble in blowing out the larger, or the pressure in the smaller bubble being greater than in the larger, might have been to some extent anticipated if we had considered more fully the plane film across the end of the open pipe. Suppose such a film stretched across a circular ring of wire. This film might be looked upon as part of the surface of a great bubble of infinite radius. Since the pressure on both sides of the film is the same, it follows that in such a bubble the pressure inside would equal the pressure outside. It is not necessary, therefore, for the film to exert any pressure in either direction in order to maintain the equilibrium of the system. For a plane surface or a sphere of infinite radius it is evident that the pressure of the film is zero.

Let us now consider a ring of smaller radius than the first, contain-

¹ For particulars in regard to the preparation of the soap solution, see *Soap Bubbles*, C. V. Boys, published by Young & Co., New York. This book also contains an account of many interesting and instructive experiments with films.

ing a segment of a bubble of such radius that the surface area of the segment is just equal to the surface area of the plane film held in the first ring. The surface energy is the same in the two cases. In the first case, however, it is directed in the plane of the ring, while in the latter case it can be divided into two portions, one of which acts in the plane of the ring and the other in a direction at right angles to this plane. This film, therefore, exerts a pressure, while the other does not, although both have the same energy. This pressure, therefore, evidently depends upon the form of the surface. This is of the greatest importance in connection with the problems relative to the movement of soil moisture. It is the form of the capillary surface which determines whether or not it is in equilibrium with other water surfaces in the soil—whether it shall expand or contract, advance or recede.

PRESSURE OF A FILM.

It has been shown that the pressure which a film is able to exert is dependent on the form of the film. It is now of interest and importance to determine in what way the pressure is related to the curvature of the film and to its surface tension, in order that the action of films under certain conditions in the soil may be determined.

Suppose a cylindrical film of radius r and pass a plane through it at right angles to the axis.¹ Suppose the section to be represented by the plane of the paper. (See fig. 2.) Let ab be a small portion of the section of the film thus formed. Let T represent the surface tension directed tangentially at a and b in the plane of the section, the film considered being taken of unit width perpendicular to this plane and of length ab .

The resultant of the two components of T is cd or P .

$$\begin{aligned}\text{Then } P &= 2T \sin \frac{1}{2} \theta \\ \sin \frac{1}{2} \theta &= \frac{ab}{2r} \therefore P = T \frac{ab}{r}.\end{aligned}$$

If $ab=1$, we have the unit area of surface and $P = \frac{T}{r}$; or the pressure varies directly as the surface tension and the curvature, the latter being the reciprocal of the radius. In general the pressure on any film at any point can be expressed by

$$P = T \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$$

in which r_1 and r_2 represent the radii of curvature of the sections formed by passing two normal planes at right angles through the point.

For a sphere $r_1=r_2$, and we have $P = \frac{2T}{r}$ or the pressure of a spherical surface is twice the surface tension divided by the radius. It is now easy to understand why the smaller bubble blows the larger one out.

¹ In what follows, but one surface of the film is considered. Where two concentric surfaces exist, as in bubbles, the pressure would be doubled.

Since the surface tension is the same on both bubbles, if the smaller bubble is only one-half the diameter of the larger its internal pressure would be twice as much.

SURFACE OF NO PRESSURE.

It is evident from the equation that there are only two surfaces of revolution in which the pressure can be zero. For if we put P equal to zero it is necessary either that both r_1 and r_2 be equal to infinity, or that $r_1 = -r_2$ in order that the equation may be satisfied. The first case is satisfied by the plane, which is a sphere of infinite radius. A plane film therefore has no pressure. The other case is satisfied by the catenoid surface in which $r_1 = -r_2$, that is, in which the radii are numerically equal and on opposite sides of the film. This figure is of much importance in the consideration of films. It is generated by the revolution of the catenary

curve (*catena*, chain) about its directrix. This curve is that represented by a chain or flexible cord of uniform weight hanging from two horizontal supports at a distance from each other less than the length of the cord. The equation is:

$$y = \frac{a}{2} \left(e^{\frac{x}{a}} - e^{-\frac{x}{a}} \right)$$

in which a is the distance from the

lowest point of the curve to the directrix, which is taken to coincide with the axis of x , and e is the base of the natural system of logarithms. It is evident that the curve is symmetrical about the axis of y and that its intercept on the axis of y is equal to the value of a chosen. This curve is illustrated in fig. 3, in which different forms are obtained by assigning different values to a . They represent the different positions assumed by a chain under different tensions, or by a film having different surface tensions.

One of the best examples of the catenoid is found in a soap film stretched between two equal circular rings of wire so placed that their planes are parallel and their edges bound a rectilinear cylinder. This can be easily prepared by wetting the rings in the soap solution and blowing a bubble upon them. The film inside each ring is then broken with a hot wire, after which the rings may be separated. Since the

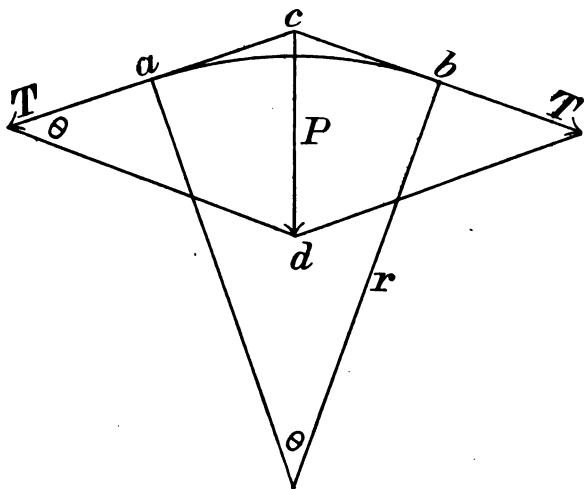


FIG. 2.—Pressure of a film.

pressure is now the same on both sides of the film we have a surface of no pressure. This surface is stable only when the tangents to the catenary at its extremities intersect before reaching the axis of the figure. The accompanying illustration (fig. 4) is taken from a photograph of a film prepared in the manner described.

A section of the catenoid midway between the wire rings and parallel to them is a circle. A circle of this diameter if cut out from a piece of paper and held with its edge against the catenary would exactly fit the surface for a short distance each side of the center, or the surface is one of no curvature. Since the potential energy of any system always tends to reach its minimum, the film tends to contract to its smallest possible

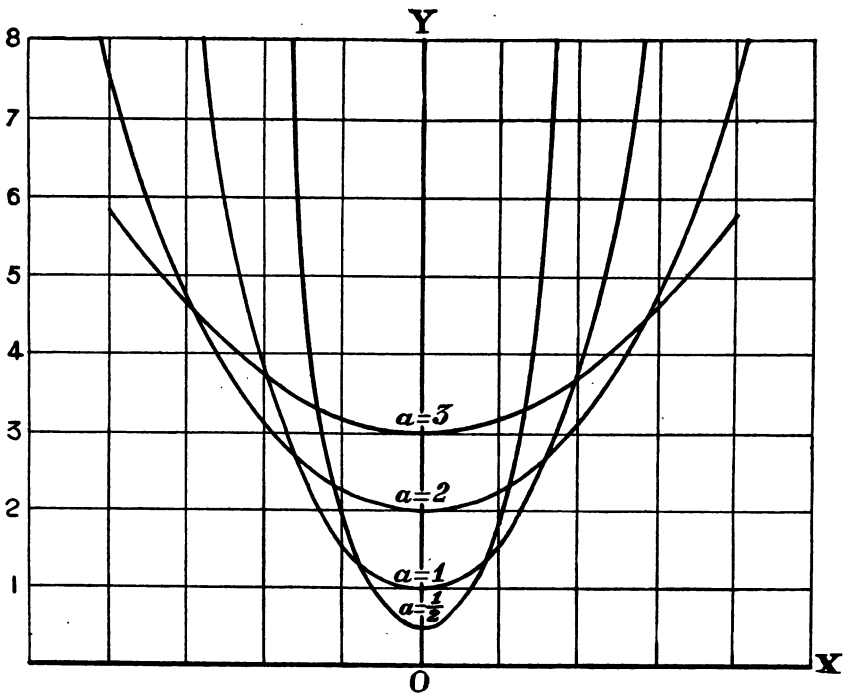


FIG. 3.—Forms of the catenary.

area and the film between the two rings represents the surface of least area which can be formed between them.

Let a small soap bubble be blown between two rings as in the preparation of the catenoid soap film. Now separate the rings until the film between the rings forms a cylinder with straight walls, as in fig. 5. The pressure inside the cylinder is evidently greater than the atmospheric pressure, as is shown by the bulging outward of the films inside the rings. In fact, from a measurement of the curvature of these spherical segments at the end of the cylinder, we find the pressure in the cylinder to be equal to that of a spherical bubble of twice the diameter of the cylinder.

Now insert the pipe in the cylinder through one of the ends and allow the pressure inside and out to become equalized. The films inside the rings become plane, since the plane is a surface of no pressure. The cylinder degenerates into a catenoid, also a surface of no pressure. Suppose now the pressure is reduced still more, so that the films inside the rings bulge inward, showing the pressure on the inside to be less than outside. This gives a surface having a more pronounced waist than the catenoid. It represents the form assumed by the free surface of a liquid between two solid surfaces, which it wets and is therefore called

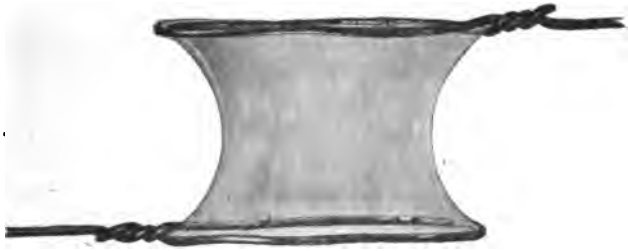


FIG. 4.—Catenoidal film.

a capillary surface. This form of surface is therefore the one that is met with in the capillary space formed by the contact of two soil grains. The generating curve of a capillary surface is known as the "elastic curve," from its identity with the curve formed by a straight spring of uniform flexibility when its ends are acted upon by equal and opposite forces. Some of the forms assumed by this curve under different conditions can be easily obtained with a steel spring.¹



FIG. 5.—Cylindrical film.

To summarize briefly, the pressure which a film may exert depends upon its surface tension and its form: (1) The pressure of the film may be inward, as in the case of the cylinder, indicated by the films inside the rings being forced outward; (2) the pressure may be zero, as in the case of the catenoid, the films inside the rings

being plane; (3) the pressure may be outward, as in the case of surfaces generated by the elastic curve, the films within the ring being drawn inward.

If the interior of two closed films of unequal size, both having a pressure inward and both free to move, are connected, the smaller film having the greater pressure will contract, forcing the larger film to expand. This is illustrated by two soap bubbles or by the coalescence of drops of mercury. If the two films have a pressure outward, the smaller film,

¹For tracings obtained in this way see Thomson & Tait, *Natural Philosophy*, Part I, p. 148.

having the greater curvature, will expand until the two films become equal. This is what would take place in surfaces generated by the elastic curve—that is, capillary surfaces—if these surfaces were free to move, and is of the greatest importance in the adjustment of the water content of a soil among the capillary spaces.

FORM OF WATER SURFACE BETWEEN TWO SOIL GRAINS.

The manner in which water is held in a soil may now be considered. Suppose the soil grains to be momentarily separated so that no two grains are in contact. Each grain carries with it a small amount of moisture, which, through the agency of surface tension, spreads over the surface of the grain. Suppose now that two of these grains, which may be assumed spherical in form, are once more brought in contact. The water is drawn into the capillary space formed between the spheres and forms between the grains a capillary water surface.

The collection of a portion of the water previously distributed over the surface of the grains into this capillary space may be explained from a consideration of the curvature and pressure of the water surfaces, which will hereafter be designated as films. When the two spheres are brought in contact, the films in meeting form a surface of very great curvature having a pressure outward. Since the two films on the surface of the spheres have a pressure inward, the water moves rapidly toward the capillary space. As the new surface increases, its pressure becomes less and the movement of water becomes slower, finally ceasing when the pressure is not sufficient to overcome the resistance offered by the films.

The arrangement of the water between the spheres may also be considered from the standpoint of the potential energy of the system. It has been shown that a film between two rings assumes the form of the catenoid, as representing the least surface, and consequently the minimum potential energy. Therefore, any liquid surface held between two parallel planes will tend, so far as the conditions will admit, to approach the catenoid in form, which is the limiting form of the capillary surface. This is well illustrated by the ink between the blades of a right-line ruling pen. These parallel planes may be supposed to separate gradually as the amount of water increases, and this gives the condition on the spherical surfaces.

On the assumption that no evaporation can take place and that the spheres are entirely covered with moisture before being brought in contact, it follows that the spheres will still be covered after contact, although the film will be much thinner than before. The amount of diminution in the surface, due to the contact of the spheres, is evidently equal to the difference between the combined area of the original water surfaces and the combined area of the spherical segments outside the capillary surface, together with the area of the capillary surface. If the thickness of the original films on the spheres was small in compari-

son with their radii, the diminution in surface is practically equal to the difference between the combined areas of the spherical surfaces inclosed in the capillary space and the area of the inclosing capillary surface. If the equation of the capillary surface, which is too complex to be considered profitably here, is known, the area of the surface can be calculated and the change in potential energy determined.

ESTABLISHMENT OF EQUILIBRIUM BETWEEN TWO UNEQUAL MASSES OF CAPILLARY WATER.

Suppose the capillary spaces formed by several spheres in contact to contain different amounts of water. These spheres are supposed originally to have been covered with films and then brought in contact, so that water films will exist on all surfaces which are not submerged. Let one of these films connect the water held in two adjacent capillary spaces containing different quantities of water. This is illustrated

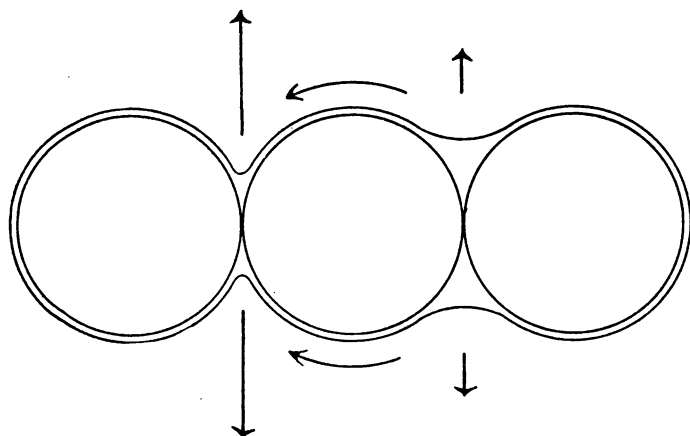


FIG. 6.—Adjustment of water between two capillary spaces.

diagrammatically in fig. 6, which represents a section through the centers of three spheres in contact.

Since the capillary spaces are similar in form, it follows from previous considerations that the surface of the smaller mass of water will have the greater curvature, and consequently the greater pressure outward. The direction and relative magnitude of the pressures of the two films taken within the section are represented by the length of arrows. Since the surface of the lesser mass of water exerts the greater pressure outward, water will move through the connecting film in the direction of the curved arrows from the greater to the lesser mass. This action will continue until the pressure becomes the same, which in this case takes place when the capillary spaces contain equal amounts of water, since the spaces are of the same form. In any case, equilibrium is reached when the two films attain the same curvature.

The rate at which this adjustment of water between two capillary

spaces will take place depends upon the viscosity of the connecting film, the surface tension, and the difference in curvature of the films. The viscosity of the connecting film does not in any way interfere with the final adjustment of the water, but it retards to a greater or less degree the establishment of equilibrium. An increase in either the curvature or the surface tension causes an increase in pressure, as has been previously pointed out.

It is evident that this movement can be extended to any number of capillary spaces through any number of films, so that adjustment takes place over a large mass of soil when disturbing influences are introduced. This change takes place more or less slowly, according to the amount of water present in the soil. If the soil is nearly saturated, so that the films connecting the capillary spaces are short and thick and the capillary spaces themselves are not active, but little resistance is offered to the movement of water and the addition of water at the surface is quickly felt farther down. If, on the other hand, the soil contains but little water, the same amount of water added to the surface, while producing marked changes in the upper layers, will not be felt so quickly at the lower depths on account of the activity of the upper capillary spaces and the length and small cross section of the connecting films. But an adjustment of the water between the upper and lower capillary spaces takes place in this case also until equilibrium is gradually reached.

SALTS AS AFFECTING THE MOVEMENT OF WATER IN SOILS.

We have seen the importance of surface tension in opposing the gravitation of capillary water of soils. Any change in the surface tension of the soil moisture tends to bring about an adjustment of the water throughout the whole mass of soil. If the surface tension of the water in the upper layers of a soil is increased, water is drawn toward that point. Since the surface tension of most salt solutions is higher than that of water, and the surface tension increases with the concentration of the solution, it might be expected that any salt used as fertilizer a solution of which has a high surface tension would increase the amount of water in the soil.

It must be remembered, however, that the surface tension of solutions is very greatly decreased by the addition of very small quantities of certain organic substances produced through the decomposition of vegetable matter. This action is especially marked where there are present substances of an oily nature which do not go into solution, but spread out over the surface in an extremely thin film. Owing to such substances being continually produced by the decay of organic matter, the surface tension of the soil moisture is kept very low and could be only slightly influenced by the addition of salts. The application of substances to the soil for the purpose of changing its water content through a change in the surface tension, would not therefore necessarily be productive of marked results.

TEMPERATURE AS AFFECTING THE MOVEMENT OF WATER IN SOILS.

It was pointed out in a preceding section that the surface tension of water decreases with increase of temperature. Therefore if the bottom of a column of soil in which the water has attained a condition of equilibrium should be cooled, the surface tension of the lower strata would be raised and the water would be drawn toward the bottom, or if the lower strata should be heated the water would tend to move toward the top. The first method of procedure should give the most marked results, since the movement in this case is assisted by gravitation. A movement should also be secured by raising or lowering the temperature of the whole mass of soil uniformly. In the first case the water content of the upper strata would be decreased and in the second case increased. These conclusions are indirectly verified by some interesting experiments of Professor King¹ in experimenting with the fluctuations of ground water in a large, cylindrical, galvanized iron tank. He found that the water in a circular well in the middle of the cylinder rose daily and fell again during the night. The application of cold water to the outside of the cylinder by means of a hose also caused the water in the well to fall. These results are fully consistent with the phenomena of surface tension. When the temperature of the soil was raised the surface tension of the water was lowered and more water was drawn into the lower part of the cylinder, which raised the level of the water in the well. When cold water was applied to the outer surface of the cylinder, the water in the soil was drawn up again through increased surface tension and the level of the water in the well was lowered.

The influence of temperature on the rate of flow of water in saturated soils is very great. This is due to a change in the viscosity of water with temperature, as has been pointed out in the section on viscosity. This property is not only of interest in considering saturated soils, but it is also an important factor in determining the rate of adjustment of water in soils in which saturation is not complete.

INFLUENCE OF TEXTURE AND STRUCTURE OF SOILS ON THE ACQUIREMENT AND RETENTION OF SOIL MOISTURE.

The limit of the capacity of any soil for water is reached when the surface tension holding the water in the capillary spaces is no longer able to overcome the force of gravity acting on the mass. The relative water capacity of two soils, therefore, depends principally upon the number and size of the capillary spaces. By a capillary space as used here is meant not any interstitial space in the soil structure, but only that portion of it which is near the point of contact of two soil grains. It is that portion in which the bounding walls are close together, separated only by distances of capillary magnitude and consequently most efficient in retaining water. It is evident that in a soil of fine texture

¹ U. S. Department of Agriculture Bul. No. 5, Weather Bureau, pp. 59-61.

the grains might be so close together as to make all the interstitial space capillary in its nature.

The one important factor which determines the acquirement and retention of soil moisture is the curvature of the capillary water surfaces. If equal volumes of two soils are placed in contact, and the curvature of the surface is less in the first than in the second, then water will move from the first to the second, increasing the curvature in one and decreasing it in the other until it becomes the same in both soils. If the second soil contains a greater number of capillary spaces than the first, it will contain more water when equilibrium is established. During the adjustment water will have actually moved from a soil containing a low percentage of water to one having a higher percentage. In no case, however, will water leave a capillary space having a water surface of large curvature to go to a space with a surface of less curvature. It is the form of the surface which determines the movement of the water.

In a form of structure presented by Dr. Soyka, to which reference has previously been made, and in which the spheres are arranged for the greatest amount of interstitial space, there are only about one-half as many points of contact between the grains as in another form of structure given, although the amount of interstitial space in the first case is twice as great. Consequently the second form—the compact soil—would have twice the water capacity of the first, since the number of capillary spaces formed is twice as great. The difference in this case would be due entirely to the structure of the soil, since the texture remains uniform.

In the same manner a soil of fine texture contains many more capillary spaces than a soil which is coarse, and consequently has a much greater water-holding power. In a coarse sandy soil the interstitial spaces are large, allowing percolation and drainage to take place rapidly, but permitting the formation of comparatively few capillary spaces for the storing of water. As the texture becomes finer the interstitial space becomes smaller and the capillary spaces increase in number, and embrace a large proportion of the whole interstitial space. The water capacity of the soil increases and percolation is greatly decreased. The limit is reached when the texture becomes so fine and the structure so close that all the interstitial space becomes capillary in its nature. The capacity of the soil for moisture in this case is reached only when all the interstitial space becomes filled with water, a condition found in some clay soils.

DISPLACEMENT OF CAPILLARY WATER THROUGH GRAVITATION.

In considering the adjustment of water among the capillary spaces and the arrangement of the film so as to present as little free space as possible, it was assumed that the action of gravity could be neglected. This is undoubtedly the case in the smaller capillary spaces, but in those existing between the larger soil grains gravitation causes a displacement of the capillary water, so that it is no longer symmetrically

arranged about the point of contact. The action of gravity on the capillary water between two spheres is illustrated in fig. 7.

The model consists of rubber balls about 1 inch in diameter fastened together by small steel pins inserted normal to the surface at the points of contact. The whole is then immersed in cylinder oil and allowed to drain while in a vertical position. While the great size of the balls and the low surface tension of the liquid are conditions not found in soils, it nevertheless illustrates the principle involved. If the liquid had no weight it would be uniformly distributed about the line of centers of spheres. Gravitation, however, causes a distortion of the liquid from a position of symmetry about the point of contact. When the line of centers is horizontal, the liquid moves down until the pressure exerted by the upper portion of the film is equal to that exerted by the lower portion plus the weight of the liquid. The curvature of the upper part of the film must therefore be greater than that of the lower. The upper film is consequently drawn down into the capillary space until it acquires sufficient curvature to support the weight of the liquid and the tension of the opposing film. Reference to the figure will show the upper part of the film far down in the capillary space, while the lower part is well down on the surface of the spheres.

If the line of centers is vertical the curvature from the upper contact will gradually increase downward in order to compensate the effect of the weight of the liquid. This can be seen in the vertical films in the figure, and is well illustrated by the position assumed by a drop of ink between the opened blades of a ruling pen, held so that the blades lie in horizontal planes one above the other.

A consideration of the displacement of the water in the capillary spaces through the influence of gravity serves to give an idea of what takes place when the soil contains more water than the capillary spaces are able to retain. The upper part of the film is then unable to reach a position where it can balance the opposing forces, and water is moved through gravitation until the film is enabled to secure a position in which it can establish equilibrium. Such displacements of capillary water would occur only in the larger capillary spaces where a considerable mass of water would be subjected to the action of gravitation.

In considering the gravitation of water in soils, mention was made (p. 7) of the marked difference in water content of a vertical column of soil at different points along the column. Having developed the principles which regulate the movement of water in soils, the explanation of this non-uniform distribution of water in a vertical column can now be given.



FIG. 7.—Displacement of capillary water through gravitation.

Consider a single vertical column of soil grains as arranged in fig. 7, and suppose the capillary spaces to contain equal amounts of water. The amount of water in each capillary space is assumed to be less than the amount required to saturate it considered by itself, so that if the column were in a horizontal position the water would all be retained. Each capillary surface would in this case be supporting the water in the capillary space, together with the weight of the water in the connecting film on the surface of a soil grain. When the column is raised to a vertical position, the weight of the whole conducting film from top to bottom is thrown for an instant upon the capillary surface nearest the top. This capillary space immediately loses water until the pressure of the surface is equal to the pressure of the surface next below, plus a pressure sufficient to balance the weight of the water in the connecting film between the two surfaces. Both spaces then lose water together, maintaining this difference in pressure until the pressure of the second surface is equal to that of the third plus the pressure necessary to balance the weight of the connecting film, as before. The pressure of the first surface would now be equal to the pressure of the third, plus the pressure necessary to balance the weight of the two connecting films. The action would continue in this manner through each capillary surface until equilibrium is established.

The relative part taken by the different capillary surfaces in supporting the weight of the connecting column can be illustrated by means of the following mechanical analogue. Suppose a series of very thin elastic membranes stretched over circular hoops and supported horizontally one above the other, the distance between the membranes being very small. Now, let a heavy ball be placed upon the upper membrane. This membrane immediately stretches until it reaches the second, then the two stretch together until they touch the third, and so on, until the ball comes to rest. Suppose the membranes all had the same tension before the ball was put in place. After equilibrium is established the upper membrane will have the greatest tension, the second one the next greatest, and so on, analogous to the pressure of the capillary surfaces.

The pressure of the upper capillary surface will always exceed that of the lower surface by the pressure necessary to support the weight of the conducting column. This would necessitate the upper films having a much greater curvature, so that less water could be held in the capillary spaces. The water content should therefore increase uniformly from top to bottom. This has been shown to be the case with coarse sands.

In a soil of fine texture the number of capillary spaces is greatly increased. The pressure exerted by the capillary surfaces would therefore be much greater for the same water content. Consequently, the effect of the weight of the connecting films would be much lessened, and the water content of the soil would be much more uniformly distributed.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF SOILS.

TOBACCO SOILS OF THE UNITED STATES:

A PRELIMINARY REPORT UPON THE SOILS OF
THE PRINCIPAL TOBACCO DISTRICTS.

BY

MILTON WHITNEY,
CHIEF OF DIVISION OF SOILS.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1898.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., November 1, 1897.

SIR: I have the honor to submit herewith and to recommend for publication a preliminary report upon the principal tobacco soils of the United States. It has not been possible, with the time and means at our disposal, to make an exhaustive study and map accurately the areas of the tobacco lands, but trips of reconnoissance have been taken over most of the important tobacco districts and a large amount of material has been examined. The results show a very marked difference in the texture and physical properties of the soils adapted to the different classes, types, and grades of tobacco, and give a basis for the classification of the soils and their mapping upon any desired scale. A recommendation has been made in my annual report that a more detailed study of these soils be undertaken and that reliable maps be prepared showing the area and distribution of the soils.

Respectfully,

MILTON WHITNEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	5
Statistics of tobacco culture.....	6
Tobacco produced in four census years.....	7
Estimates of tobacco production in 1896	8
Principal tobacco districts	8
Changes in production of tobacco from 1879 to 1889	9
Counties constituting the tobacco districts of the United States.....	10
Influence of climate on the distribution of the different classes of tobacco....	12
Meteorological conditions in the great tobacco regions.....	12
Experience the only safe test of climate for tobacco.....	14
Soils of the tobacco districts	14
The texture of tobacco soil.....	15
Soils of the Northern cigar tobacco districts.....	16
Soils of the Southern cigar tobacco districts.....	21
Bright tobacco lands.....	24
Manufacturing tobacco lands of Virginia and North Carolina.....	25
The white burley tobacco lands of Kentucky and Ohio.....	26
Export tobacco lands of Kentucky and Tennessee.....	27
The relative water content of tobacco soils.....	28
Mean water content of the Northern cigar tobacco soils.....	29
Water content of the Florida tobacco soils.....	30
Water content of the soils of the manufacturing and export tobacco districts	30
Tables of the water content of tobacco soils.....	32
Tables of the mechanical analyses of tobacco lands.....	40

ILLUSTRATIONS.

Plate I. Diagram showing comparison of climatic conditions for four tobacco districts.....	12
II. Diagram showing comparison of climatic conditions for four tobacco districts.....	12
III. Texture of cigar tobacco land in Massachusetts	18
IV. Texture of cigar tobacco land in Connecticut.....	18
V. Texture of cigar tobacco land in Pennsylvania	20
VI. Texture of cigar tobacco land in New York	20
VII. Texture of cigar tobacco land in Ohio	20
VIII. Texture of cigar tobacco land in Wisconsin	22
IX. Texture of bright tobacco land in Virginia.....	24
X. Texture of manufacturing tobacco land in Virginia	26
XI. Texture of white burley tobacco land in Kentucky.....	26
XII. Texture of export tobacco land in Kentucky.....	28
XIII. Diagram showing relative proportions of sand, silt, and clay in tobacco soils	28

TOBACCO SOILS OF THE UNITED STATES: A PRELIMINARY REPORT UPON THE SOILS OF THE PRINCIPAL TOBACCO DISTRICTS.

INTRODUCTION.

In 1892, when the tobacco exhibit was being prepared for the Columbian Exposition, it was proposed to make a very comprehensive study of the soils of the principal tobacco areas of the country. This idea could not be carried out in full at the time, but a beginning was made and quite a large collection of typical tobacco soils secured. Since that time much attention has been given to the subject, a large number of samples have been collected by agents of the Department, and quite a large amount of this material has been examined in the laboratory. This publication is a preliminary report upon the work.

In recent years quite a little work has been done upon various lines connected with the production of tobacco, and a number of valuable publications have been issued. The most comprehensive and generally valuable paper was published in the volume of Agriculture of the Tenth Census. This article contains a great amount of exceedingly valuable information in regard to the soils and the influence of the soils on the tobacco crop of the United States.

Prof. O. Comes has published a valuable contribution on the botany of the tobacco plant in a short monograph, entitled *Hortus Botanicus Porticensis*, in which he attempts to classify botanically the tobaccos of the principal tobacco districts of the world. This was followed by the publication in 1897, by the same author, of the first volume of *Del Tabacco—Storia, geografia, statistica, speciografia, agrologia e patologia*.

Several valuable papers have been published in the annual reports of the Connecticut Experiment Station upon the progress of an investigation in tobacco culture at Poquonock for the past five years. Several bulletins have been issued from other experiment stations on this subject, notably the following: Bulletin No. 4 of the Colorado Experiment Station, published February, 1888, giving a description of the best tobacco soils, methods of cultivation, curing, and other treatment of the

crop, together with the yield and quality of tobacco from a number of samples of seed sent out by the United States Department of Agriculture. Bulletin No. 20 (second series), of the Louisiana Experiment Station on Tobacco Growing in Louisiana, consists of an essay on the general subject of tobacco growing, together with experiments at the North Louisiana Experiment Station. This was followed the next year by the publication of Bulletin No. 25 (second series), containing the results of experiments made on the cultivation of tobacco in northern Louisiana. Bulletin No. 122, on Types of Tobacco and Their Analyses, published by the North Carolina Experiment Station in 1895, contains the results of the chemical analyses of a number of typical tobaccos from the principal tobacco areas of the country. In 1895 the Florida Experiment Station published a report on the Culture of Tobacco, followed in 1897 by a revised and somewhat enlarged edition. This was published as Bulletin No. 38, and called Tobacco in Florida. In 1896 the Kentucky Experiment Station published Bulletin No. 63 on Tobacco, containing the results of some fertilizer experiments on the yield of tobacco, together with a study of the effects of arsenites on the tobacco plant and its efficiency as an insecticide. Mention should also be made of a number of valuable papers on the cultivation of tobacco by our consular agents in the Consular Report, particularly those relating to the cultivation of tobacco in Sumatra and in Cuba. Another important contribution entitled Tobacco Leaf, by Killebrew and Myrick, published in 1897, covers the general subject of tobacco culture and curing.

STATISTICS OF TOBACCO CULTURE.

In order to study the question intelligently it was necessary carefully to consider the yield of the different States, the counties in each State and district which produced any considerable amount of tobacco, and be largely guided by this in collecting samples of soils for examination. The data for this work were taken mainly from the Tenth Census, on account of the detailed estimates and the very valuable descriptions given there of the tobacco areas, the soils, and the physical conditions in the areas. In order to judge how the conditions had changed in the ten years which had elapsed since the census was taken, the yield from the counties composing the principal districts was compared with the yield of the same counties given in the Eleventh Census, a preliminary bulletin of which, on Tobacco Production, was published shortly after these investigations were undertaken.

As there are no subsequent figures which admit of the detailed study that these census figures allow, they are given here to show the location of the different tobacco areas and incidentally to show the change in acreage and yield in the ten years elapsing between the Tenth and Eleventh Censuses.

TOBACCO PRODUCED IN FOUR CENSUS YEARS.

The table below furnishes a condensed and exact exhibit of the production of the tobacco regions of the United States and the changes that took place from 1859 to 1889.

States producing tobacco in 1889.	1859.	1869.	1879.	1889.
<i>Over 1,000,000 pounds.</i>				
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1. Kentucky.....	108,126,840	105,305,869	171,120,784	221,880,303
2. Virginia.....	121,787,946	37,086,364	79,988,868	48,522,655
3. Ohio.....	25,092,581	18,741,973	84,735,235	37,853,563
4. North Carolina.....	32,853,250	11,150,087	26,986,213	36,375,258
5. Tennessee.....	43,448,097	21,465,452	29,365,052	36,368,396
6. Pennsylvania.....	3,181,586	3,467,539	36,943,272	28,956,247
7. Wisconsin.....	87,340	960,813	10,608,423	19,389,166
8. Maryland.....	38,410,965	15,785,339	26,082,147	12,356,838
9. Missouri.....	25,086,196	12,320,483	12,015,657	9,424,823
10. New York.....	5,764,582	2,349,798	6,481,431	9,316,135
11. Connecticut.....	6,000,133	8,328,798	14,044,652	8,874,924
12. Indiana.....	7,993,378	9,325,392	8,872,842	7,710,297
13. Illinois.....	6,885,262	5,249,274	3,935,825	3,042,936
14. Massachusetts.....	3,233,198	7,312,885	5,369,436	2,794,848
15. West Virginia.....	2,180,966	2,046,452	2,296,146	2,602,021
<i>Between 100,000 and 1,000,000 pounds.</i>				
16. Arkansas.....	989,980	594,886	970,220	954,640
17. Florida.....	828,815	157,405	21,182	470,443
18. Georgia.....	919,318	288,596	228,590	263,752
19. South Carolina.....	104,412	34,805	45,678	222,898
20. Texas.....	97,914	59,706	221,283	175,706
21. Alabama.....	232,914	152,742	452,426	162,430
<i>Less than 100,000 pounds.</i>				
22. New Hampshire.....	18,581	155,334	170,843	86,593
23. Iowa.....	303,168	71,792	420,477	74,396
24. Vermont.....	12,245	72,671	131,432	70,518
25. Kansas.....	20,349	33,241	191,669	62,083
26. Mississippi.....	159,141	61,012	414,663	61,511
27. Louisiana.....	39,940	15,541	55,954	46,845
28. New Jersey.....	149,485	40,871	172,315	33,855
29. Delaware.....	9,699	250	1,278	29,680
30. Minnesota.....	38,938	8,247	69,922	23,285
31. California.....	3,150	63,809	73,317	12,907
32. Michigan.....	121,099	5,345	83,969	11,984
33. Nebraska.....	3,636	5,988	57,979	11,049
34. Washington.....	10	1,682	6,930	7,040
35. Oregon.....	405	3,847	17,325	8,325
36. New Mexico.....	7,044	8,587	890	1,415
Total.....	494,291,913	262,732,755	471,655,305	482,244,764

This table gives the yield of States according to the production in 1889, the first group comprising those States in which the production exceeded 1,000,000 pounds, the second group comprising those States in which the production is between 100,000 and 1,000,000 pounds, the third group embracing the States producing less than 100,000 pounds.

ESTIMATES OF TOBACCO PRODUCTION IN 1896.

The following are the final estimates of the Division of Statistics of this Department for the year 1896:

Area, yield, and value of tobacco in 1896.

State.	Area cultivated.	Yield.	Value.
	<i>Acres.</i>	<i>Pounds.</i>	
Kentucky	196,745	143,623,850	\$6,032,202
North Carolina	134,567	68,629,170	5,490,334
Virginia	92,002	57,961,260	3,013,986
Tennessee	53,351	35,211,660	2,464,816
Ohio	32,012	23,688,880	1,066,000
Maryland	15,995	9,277,100	398,915
Pennsylvania	13,884	16,244,280	1,299,542
Indiana	11,957	8,130,760	365,884
Missouri	10,580	7,406,000	666,540
Connecticut	6,579	10,197,450	1,325,668
West Virginia	5,119	3,685,680	313,283
Wisconsin	3,975	5,088,000	279,840
Illinois	3,902	2,497,280	237,242
New York	3,259	3,389,360	271,149
Arkansas	2,950	1,327,500	146,025
Alabama	2,147	1,009,090	161,454
Massachusetts	1,975	3,199,500	383,940
Other States	3,750	2,437,500	341,250
Total	594,749	403,004,320	24,258,070

PRINCIPAL TOBACCO DISTRICTS.

The Department is constantly in receipt of letters asking for information and advice in regard to the growing of tobacco. The main points of inquiry seem to be in regard to the kind of tobacco which should be grown and the method of curing the product.

Climate and soil conditions should determine the kind of tobacco raised. The tobacco plant readily adapts itself to a great range of climatic conditions, will grow on nearly all kinds of soil, and has a comparatively short season of growth. It can, therefore, as a matter of fact, be grown in nearly all parts of the country, even where wheat and corn can not be economically produced. But while tobacco can be so universally grown, the flavor and quality of the leaf are greatly influenced by the conditions of climate and soil. The industry has been very highly specialized and there is only demand now for tobacco possessing certain qualities, adapted to certain specific purposes. A nondescript tobacco is not worth growing and should not be grown, as it lowers the price of really good types of tobacco, to the detriment alike of the grower and the consumer. It is important, therefore, to understand what kinds of tobacco are in demand and what the climatic and soil conditions are which will most easily produce the qualities desired.

The principal kinds of tobacco grown in this country are the cigar types, for our domestic supply of cigars; the manufacturing types, for smoking and chewing, for our domestic use; the bright yellow tobacco, for cigarettes, smoking, and plug wrappers; White Burley, for smoking and chewing, both for domestic and export trade; and the export types proper, which are not suited to our domestic use, but which are mainly exported to foreign countries to be used both for cigar and

manufacturing purposes. The question is often asked, Which of these classes of tobacco should be grown?

CHANGES IN PRODUCTION OF TOBACCO FROM 1879 TO 1889.

The following table, compiled from the Eleventh Census, shows where these different classes of tobacco are produced, the acreage of the different tobacco districts in 1879 and 1889, together with the increase or decrease in acreage and yield in 1889 as compared with the acreage and yield of 1879. The plus sign in the table indicates an increase; the minus sign indicates a decrease.

Comparison of acreage and yield for 1879 and 1889, by districts.

Districts.	Relation of acreage in each district to total acreage in 1889.	Acreage.		Change in each district.		Change in whole area.	
		1879.	1889.	Acres.	Yield.	Acres.	Yield.
Cigar leaf:	<i>Per cent.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Seed leaf, Ill.....	0.3	752	329	— 56.2	— 62.7	— 0.58	— 0.68
Massachusetts.....	2.2	3,358	2,012	— 40.1	— 92.1	— 1.84	— 2.67
Connecticut.....	6.9	8,666	6,331	— 26.9	— 36.8	— 3.20	— 4.93
Indiana.....	9.2	9,859	8,378	— 15.0	— 7.0	— 2.03	— .53
Pennsylvania.....	29.2	26,347	26,746	+ 1.5	+ 19.4	+ .54	+ 7.24
Seed leaf, Ohio.....	23.2	15,017	21,224	+ 41.2	+ 5.9	+ 8.52	+ 1.04
New York.....	9.1	4,264	8,289	+ 94.3	+ 56.1	+ 5.52	+ 3.33
Wisconsin.....	18.6	8,509	17,000	+ 99.8	+ 83.3	+ 11.66	+ 9.05
Florida.....	.04	35	1,100	+3042.8	+3570.5	+ 1.32	+ .44
Total.....	98.74	76,807	91,409			+21.91	— 2.19
Manufacturing and export:							
Red and spangled, W. Va.....	.05	568	187	— 68.0	— 72.3	— .10	— .11
Manufacturing, Mo.....	.4	2,977	1,205	— 59.5	— 59.4	— .50	— .42
Sun and air cured fillers, Va.....	.8	6,285	2,616	— 58.3	— 69.9	— 1.05	— 1.29
Maryland.....	5.4	37,741	17,778	— 52.9	— 52.6	— 5.72	— 5.73
Spangled, Ohio.....	1.1	7,581	3,604	— 52.4	— 51.6	— 1.14	— 1.41
Green River, Ky.....	.9	6,419	3,123	— 51.3	— 51.3	— .91	— .91
Red shipping, Va.....	1.1	6,516	3,721	— 42.8	— 54.1	— .80	— .91
Heavy tobacco, Mo.....	2.0	10,018	6,862	— 31.5	— 28.2	— .90	— .98
Cumberland River, Ky.....	.8	3,844	2,729	— 29.0	— 27.5	— .31	— .28
Upper Green River, Ky.....	4.3	17,676	14,440	— 17.9	— 12.9	— .92	— .65
Ohio River, Ky.....	4.2	18,297	14,203	— 2.2	— 26.4	— 1.17	— 1.47
Upper Cumberland River, Tenn.....	1.6	5,421	5,398	— .4	— 14.2	+ .01	— .27
Paducah, Ky.....	8.4	28,205	28,188	— .1	— 14.0	.00	— 1.26
Lower Green River, Ky.....	14.9	50,313	50,088	.0	+ 1.2	.00	+ .21
Clarks ville, Ky.....	13.7	45,756	45,753	.0	+ 4.1	.00	+ .55
Export, Ill.....	.9	2,999	3,029	+ 1.0	+ 9.2	+ .01	+ .07
Benton County, Ark.....	.3	844	940	+ 11.4	+ 1.1	+ .02	.00
West Tennessee, Tenn.....	3.7	10,103	12,432	+ 23.0	+ 13.2	+ .66	+ .41
Clarks ville, Tenn.....	8.8	22,912	29,652	+ 29.4	+ 37.3	+ 1.93	+ 2.53
Dark shipping, W. Va.....	.5	1,342	1,819	+ 35.5	+ 80.7	+ .13	+ .18
North Carolina.....	a 22.3	a 48,005	a 74,848	+ 55.9	+ 24.4	+ 7.69	+ 2.34
Total.....		348,665	334,941			—13.87	—10.34
Bright yellow:							
Virginia.....	b 40.2	b 52,565	b 51,281	— 2.4	— 24.1	— 1.26	—13.31
West Virginia.....	1.1	1,169	1,390	+ 10.3	+ 17.0	+ .21	+ .20
North Carolina.....	58.8	b 48,005	b 74,848	+ 55.9	+ 24.4	+ 30.31	+ 10.98
Total.....		101,739	127,519			+29.26	— 2.13
White burley:							
Ohio.....	15.3	11,258	17,250	+ 53.2	+ 37.4	+ 9.25	+ 7.02
Kentucky.....	84.7	53,475	95,563	+ 78.7	+ 86.3	+ 65.01	+ 69.97
Total.....		64,733	112,813			+74.26	+76.99

a There is no way of estimating separately the acreage in yellow and in manufacturing in this State. It is generally believed the acreage in manufacturing is greatly decreased and that in yellow has increased. This estimate is but approximate.

b Including also flue-cured fillers.

A glance at the table shows that in this period of ten years the acreage and yield of the cigar tobaccos have been very considerably increased. The manufacturing and export districts can not be sharply separated, as both kinds of tobacco are frequently grown in the same district and the same kind is frequently used for both purposes. It will be seen that on the whole there has been a considerable decrease in the acreage and yield. With the bright yellow and burley tobaccos there has been a large increase in both acreage and yield. This table gives an idea where the different kinds of tobacco are raised in such quantities and of such commercial importance as to constitute a district. Since 1889 there has been considerable change in many of these districts, while other new districts, notably Texas and California, are coming into considerable prominence both as to the area under cultivation and the excellent quality of the product raised. The acreage in Florida has also been very greatly increased since 1889, but there are no reliable statistics to show the extent of the changes in the counties making up the tobacco districts.

COUNTIES CONSTITUTING THE TOBACCO DISTRICTS OF THE UNITED STATES.

The following are the counties in each State making up the different tobacco districts of the country. This gives only a very approximate idea of the area of the districts, as the boundaries follow geological and soil formations rather than county lines, and consequently only small portions of some of the counties are included in the districts. The counties are given in the order of their acreage in 1889, those having the largest acreage being given first. The numerals immediately after the names of the States show the percentage of the total tobacco acreage of the State in 1889 included in the counties named. Only those counties producing notable quantities of tobacco are here mentioned.

District of cigar types.

States and varieties.	Product of State.	Counties.
Illinois:	<i>Per cent.</i>	
Seed leaf.....	7.9	Jo Daviess, Stephenson, Carroll.
Massachusetts.....	100	Hampshire, Hampden, Franklin, Berkshire.
Connecticut.....	100	Hartford, Litchfield, Fairfield, Tolland, Middlesex, New Haven.
Indiana.....	89.4	Switzerland, Spencer, Warrick, Jefferson, Dubois, Ohio, Pike.
Pennsylvania.....	99.2	Lancaster, York, Chester, Bradford, Clinton, Tioga, Bucks, Lebanon, Northumberland, Lycoming, Dauphin, Cumberland.
Ohio:		
Seed leaf.....	47.8	Montgomery, Darke, Preble, Warren, Miami, Butler, Clinton, Clark, Shelby, Champaign, Greene.
New York.....	96	Onondaga, Cayuga, Chemung, Oswego, Steuben, Wayne, Tompkins, Tioga.
Wisconsin.....	98.6	Dane, Rock, Jefferson, Columbia, Vernon, Green.
Florida.....	92.4	Gadsden, Walton, Madison, Columbia, Leon.

District of manufacturing and export types.

States and varieties.	Product of State.	Counties.
	<i>Per cent.</i>	
West Virginia:		
Red spangled	4	Lewis, Wirt, Calhoun, Ritchie, Roane, Wetzel.
Dark shipping	38.9	Putnam, Cabell, Wayne, Kanawha, Jackson, Mason, Wood.
Missouri:		
Manufacturing	10.6	Callaway, Montgomery, Pike, Lincoln, Warren, Osage, Franklin.
Heavy	60.5	Chariton, Howard, Carroll, Saline, Macon, Linn, Randolph, Livingston, Monroe, Boone, Shelby.
Virginia:		
Sun and air cured ..	2.4	Louisa, Caroline, Hanover, Spottsylvania.
Red shipping	3.4	Dinwiddie, Fluvanna, Goochland, Rockbridge, Chesterfield.
Flue-cured fillers ..	11.1	Henry, Franklin, Patrick. (See also Bright yellow.)
Maryland	99	Prince George, St. Mary, Anne Arundel, Charles, Calvert, Montgomery, Harford, Frederick.
Kentucky:		
Green River	1.1	Ohio, Butler.
Cumberland River ..	1	Metcalfe, Adair, Cumberland, Monroe, Pulaski, Russell, Casey, Wayne, Clinton.
Upper Green River ..	5.2	Hart, Barren, Warren, Green, Marion, Allen, Taylor, Grayson, Larue, Hardin, Edmonson.
Ohio River	5.1	Caldwell, Breckinridge, Crittenden, Lyon, Hancock, Livingston, Meade.
Paducah	10.2	Graves, Calloway, Ballard, McCracken, Marshall, Fulton, Hickman.
Lower Green River ..	18.2	Henderson, Daviess, Webster, Hopkins, Union, McLean, Muhlenberg.
Clarksville	18.6	Christian, Logan, Todd, Trigg, Simpson.
Ohio:		
Spangled	8.1	Washington, Noble, Monroe, Belmont, Morgan, Guernsey, Gallia, Athens, Harrison.
Tennessee:		
Upper Cumberland River ..	10.5	Sumner, Smith, Macon, Trousdale, Jackson, Wilson, Putnam, Clay.
Clarksville	57.6	Montgomery, Robertson, Cheatham, Stewart, Dickson, Houston, Humphreys.
West Tennessee	24.1	Weakley, Henry, Obion, Benton, Dyer, Carroll, Gibson, Henderson, Hardeman, Decatur.
Illinois:		
Export	72.9	Saline, Williamson, Franklin, Hamilton.
Arkansas	50.1	Benton, Washington, Boone, Madison, Carroll, Newton, Izard, Randolph.
North Carolina	77.1	Rockingham, Granville, Stokes, Caswell, Person, Madison, Vance, Forsyth, Buncombe, Surry, Durham, Guilford, Alamance. (Including also Bright yellow.)

District of bright yellow type.

State.	Product of State.	Counties.
	<i>Per cent.</i>	
Virginia	46.3	Pittsylvania, Halifax, Henry, Franklin, Patrick.
West Virginia	29.9	Fayette, Mercer, Summers, Monroe, Raleigh.
North Carolina		(See counties under export tobacco.)

District of whit burley type.

State.	Product of State.	Counties.
	<i>Per cent.</i>	
Ohio	38.9	Brown, Clermont, Adams.
Kentucky	34.8	Mason, Owen, Bracken, Henry, Bourbon, Scott, Pendleton, Grant, Fleming, Harrison, Shelby, Boone, Nicholas, Carroll, Woodford, Montgomery, Franklin, Kenton, Lewis, Trimble, Robertson, Campbell, Gallatin, Oldham.

INFLUENCE OF CLIMATE ON THE DISTRIBUTION OF THE DIFFERENT CLASSES OF TOBACCO.

It is a curious and interesting fact that tobacco suitable for our domestic cigars is raised in the latitude of Sumatra, Cuba, and Florida, and then passing over our middle tobacco States, the cigar type is found again in Massachusetts, Connecticut, Pennsylvania, Ohio, Indiana, Illinois, and Wisconsin. The tobacco which we use only for chewing and smoking and which we send abroad is raised in the intervening States, the very best locality lying just below the latitude of southern Ohio. This is undoubtedly a matter of climate, although the ordinary meteorological statistics do not show any good reason for the facts. (See Plates I and II.)

METEOROLOGICAL CONDITIONS IN THE GREAT TOBACCO REGIONS.

The following table gives a summary of the meteorological conditions in a number of the tobacco districts of our own country, and from an eight years' record in Habana and from several years' record in the Island of Sumatra and the adjacent coast:

Mean monthly temperatures.

District.	Apr.	May.	June.	July.	Aug.	Sept.
	° F.	° F.	° F.	° F.	° F.	° F.
Connecticut Valley	44. 80	56. 50	65. 90	70. 20	67. 70	61. 11
Pennsylvania	49. 90	62. 00	71. 80	75. 90	73. 30	65. 63
Kentucky	57. 50	65. 00	75. 30	77. 20	75. 30	69. 63
Tennessee	60. 60	68. 10	77. 00	79. 50	77. 93	70. 53
Virginia	56. 00	65. 80	74. 00	77. 80	75. 40	69. 00
North Carolina	58. 20	67. 00	75. 80	78. 70	76. 00	70. 10
Sumatra	83. 05	82. 90	82. 35	82. 45	81. 35	81. 45

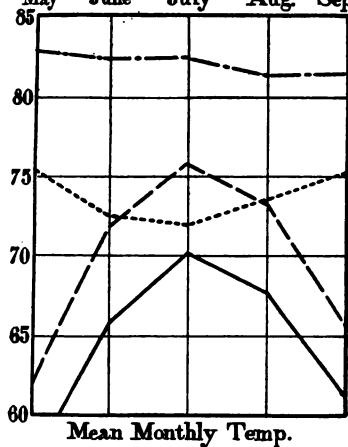
District.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Habana	78. 60	75. 40	72. 50	72. 00	73. 60	75. 20

Mean maximum temperatures.

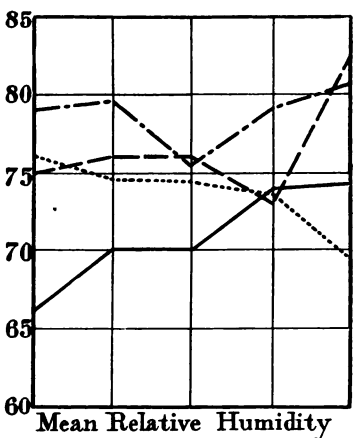
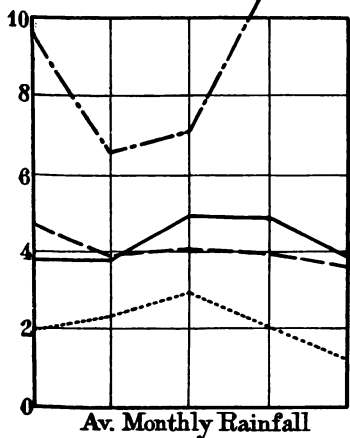
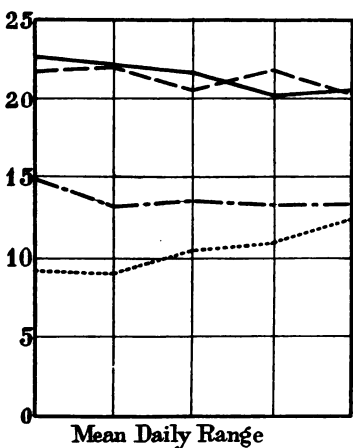
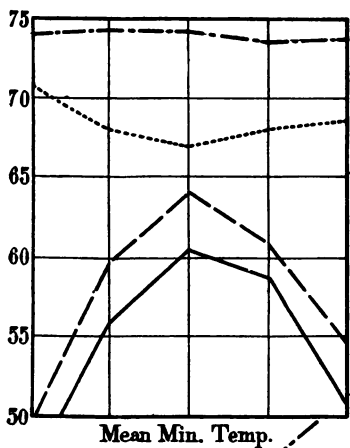
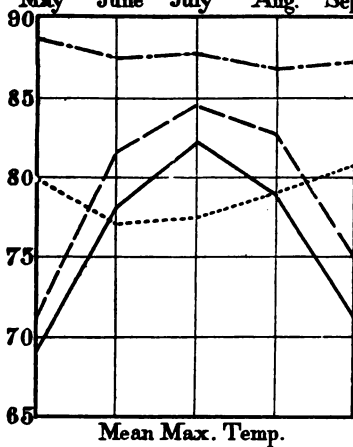
District.	Apr.	May.	June.	July.	Aug.	Sept.
	° F.	° F.	° F.	° F.	° F.	° F.
Connecticut Valley	56. 70	69. 00	78. 00	82. 10	78. 90	71. 23
Pennsylvania	60. 90	71. 20	81. 60	84. 50	82. 80	74. 98
Kentucky	70. 40	79. 80	84. 80	84. 50	81. 80	78. 90
Tennessee	70. 50	78. 80	86. 10	89. 60	87. 20	80. 75
Virginia	66. 60	76. 20	83. 60	87. 20	84. 20	78. 20
North Carolina	69. 80	78. 30	86. 10	87. 00	84. 00	78. 30
Sumatra	89. 35	88. 80	87. 50	87. 80	86. 90	87. 15

District.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Habana	82. 40	79. 90	77. 00	77. 40	79. 00	80. 80

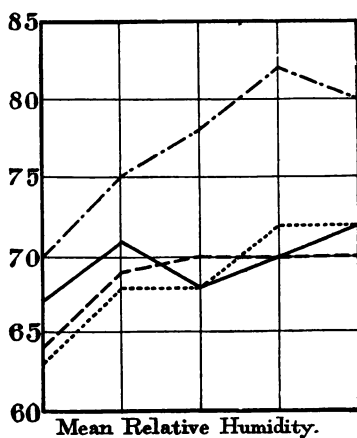
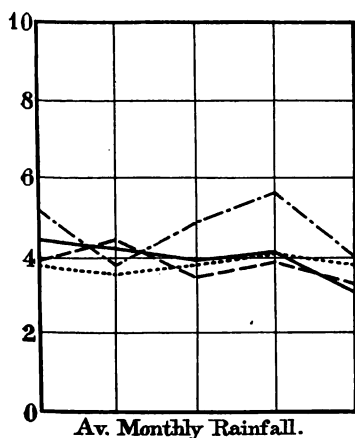
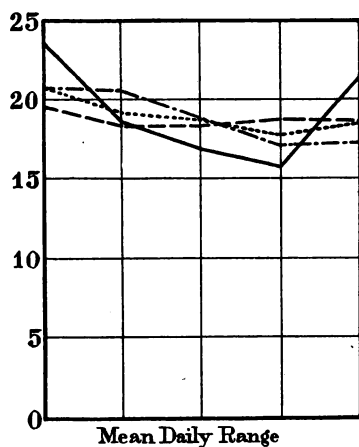
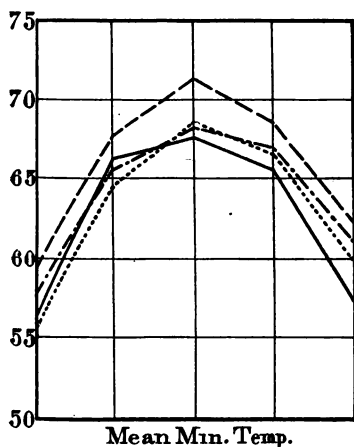
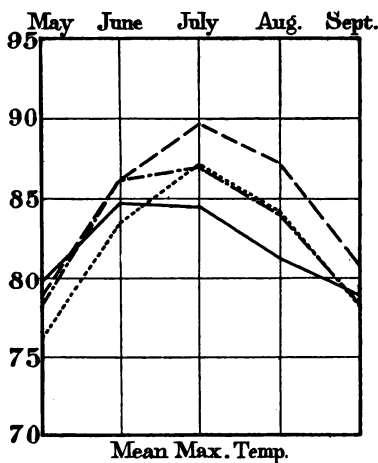
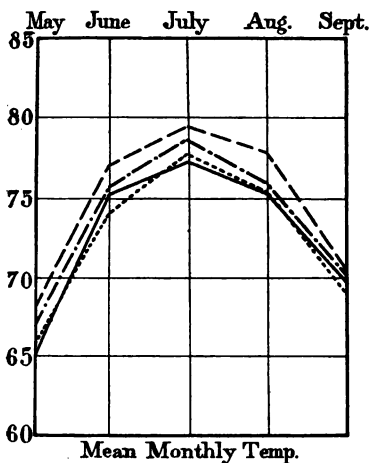
May June July Aug. Sept.



May June July Aug. Sept.



Conn. Valley — Penn. — Habana — Sumatra —



Kentucky — Tennessee — Virginia — North Carolina —

E. E. Tourney del.

Mean minimum temperatures.

District.	Apr.	May.	June.	July.	Aug.	Sept.
	°F.	°F.	°F.	°F.	°F.	°F.
Connecticut Valley	35.40	46.50	55.90	60.50	58.80	50.87
Pennsylvania	39.50	49.40	59.70	64.00	61.00	54.68
Kentucky	47.90	58.20	66.20	67.60	65.60	57.35
Tennessee	51.50	59.30	67.80	71.30	68.50	62.25
Virginia	45.40	55.50	64.50	68.50	66.50	59.90
North Carolina	47.90	57.60	65.60	68.20	66.90	61.10
Sumatra	74.40	74.00	74.25	74.15	73.60	73.70

District.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Habana	74.10	70.70	68.00	66.90	68.00	68.40

Mean daily ranges of temperature.

District.	Apr.	May.	June.	July.	Aug.	Sept.
	°F.	°F.	°F.	°F.	°F.	°F.
Connecticut Valley	21.3	22.5	22.1	21.6	20.1	20.4
Pennsylvania	21.4	21.8	21.9	20.5	21.8	20.3
Kentucky	22.5	23.6	18.6	16.9	15.7	21.6
Tennessee	19.0	19.5	18.3	18.3	18.7	18.5
Virginia	21.2	20.7	19.1	18.7	17.7	18.3
North Carolina	21.9	20.7	20.5	18.8	17.1	17.2
Sumatra	14.9	14.8	13.2	13.6	13.3	13.4

District.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Habana	8.3	9.2	9.0	10.5	11.0	12.4

Records of rainfall.

District.	Averages for months.						Totals.	
	Apr.	May.	June.	July.	Aug.	Sept.	6 months.	Year.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Connecticut Valley	3.33	3.78	3.79	4.90	4.86	3.85	24.24	49.23
Pennsylvania	3.61	4.70	3.91	4.06	3.96	3.68	23.92	43.74
Kentucky	4.98	4.46	4.25	3.97	4.12	3.06	24.86	51.70
Tennessee	5.21	3.92	4.44	3.45	3.89	3.28	24.19	52.10
Virginia	3.30	3.80	3.60	3.80	4.10	3.80	22.40	44.50
North Carolina	3.21	5.21	3.80	4.89	5.64	4.00	26.75	45.25
Sumatra	5.93	9.61	6.59	7.07	10.99	12.71	52.90	

District.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	6 months.	Year.
Habana	6.57	1.94	2.27	2.95	2.00	1.21	17.00	49.83

Mean relative humidity.

District.	Apr.	May.	June.	July.	Aug.	Sept.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Connecticut Valley	63.00	66.00	70.00	70.00	74.00	74.33
Pennsylvania	70.00	75.00	76.00	76.00	73.00	82.33
Kentucky	64.00	67.00	71.00	68.00	70.00	72.00
Tennessee	61.00	64.00	69.00	70.00	70.00	70.00
Virginia	59.00	63.00	68.00	68.00	72.00	72.00
North Carolina	67.00	70.00	75.00	78.00	82.00	80.00
Sumatra	76.50	79.00	79.50	75.50	79.00	80.50

District.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Habana	76.90	76.10	74.60	74.40	73.60	67.30

Average number of rainy days.

District.	Apr.	May.	June.	July.	Aug.	Sept.
Connecticut Valley.....	8	11	9	10	9	8
Pennsylvania.....	10	13	10	9	9	8
Kentucky.....	10	12	12	8	8	7
Tennessee.....	11	11	11	10	8	7
Virginia.....	11	12	12	11	12	9
North Carolina.....	9	13	11	14	13	10
Sumatra.....	13	14	12	11	14	15

District.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Habana.....	15	10	9	8	6	6

The Sumatra tobacco imported into this country is used only for a wrapper for our domestic cigars; it is not suitable for fillers nor for any other purpose in the market. The Habana tobacco is suitable both for cigar wrapper and filler. The Connecticut tobacco which is grown at present is valued mainly as a wrapper and binder leaf; the Pennsylvania tobacco is used mainly as a filler, the cigars being wrapped with a leaf from other localities. The same is true of the Ohio tobacco. The principal tobacco season in Cuba is about the opposite of our own. Several crops of tobacco can be grown there each season, but the main planting season is in November and December, while with us it is in May and June. It is surprising to find so little difference in the mean meteorological records for these several places during the crop season. There does not seem to be sufficient difference to explain the distribution of the different classes of tobacco, and yet this distribution is probably due mainly to climatic conditions.

EXPERIENCE THE ONLY SAFE TEST OF CLIMATE FOR TOBACCO.

One must still judge, so far as the climate is concerned, mainly from the experience of others as to the class of tobacco to be raised, as the ordinary meteorological record will be of very little value in determining this point. The plant is far more sensitive to these meteorological conditions than are our instruments. Even in such a famous tobacco region as Cuba tobacco of good quality can not be grown in the immediate vicinity of the ocean or in certain parts of the island, even on what would otherwise be considered good tobacco lands. This has been the experience also in Sumatra and in our own country, but the influences are too subtle to be detected by our meteorological instruments.

Little, therefore, can be said at the present time in regard to the suitable climatic condition for tobacco of any particular type or quality.

SOILS OF THE TOBACCO DISTRICTS.

Under given climatic conditions the class and type of tobacco depend upon the character of the soil, especially on the physical character of the soil upon which it is grown, while the grade is dependent largely

upon the cultivation and curing of the crop. The different types of tobacco are grown on a wide range of soils all the way from the coarse, sandy lands of the pine barrens to the heavy clay, limestone, grass, and wheat lands. The best soil for one kind of tobacco, therefore, will be almost worthless for the staple agricultural crops, while the best for another type of tobacco will be the richest and most productive soil of any that we have. It is particularly true of tobacco, to a greater extent, perhaps, than of any other crop, that the texture and physical properties of the soil influence the physiology of the plant to such an extent as to determine and control the distribution of the different widely distinct types of tobacco. Soils producing a heavy shipping tobacco will not produce fine tobacco of any variety. Soils containing a large proportion of clay, or which for other reasons are very retentive of moisture, tend to produce large, heavy plants which cure to a dark brown or red. A lighter, sandy soil produces a plant having a thinner and more delicate leaf, which by proper treatment can be cured to a bright red, mahogany, or fine yellow color. So marked is this influence of soil upon the quality of the tobacco that a fine, bright tobacco land may be separated by only a few feet from a heavier clay soil which will produce only a heavy manufacturing or export leaf.

Manures and fertilizers tend always to increase the yield per acre, but where large quantities of nitrogen are added to the soil there is a tendency for the leaf to become thicker, heavier, and more gummy. In the case of the fine, bright tobaccos or naturally thin-textured leaves this is apt to cause a marked deterioration in the character of the leaf; but with the heavier varieties this result is far from undesirable, because it merely increases the normal influences of the soil in making the leaf heavier, richer, and of more body. Considerable control can therefore be exercised upon the quality or grade of the leaf, not only by judicious cultivation, but by proper fertilization.

A person well acquainted with the practical work of growing tobacco can readily tell from a simple inspection of the soil what special kind of tobacco the soil will grow and in what condition the soil is for tobacco cultivation. There is some physical, tangible evidence that indicates to the experienced eye whether the conditions are favorable for tobacco growing, whether the land would produce a given type, or whether a nondescript tobacco would be produced. The evidence upon which this judgment is based appears to be the texture or coarseness of the soil grains and the water content. The present investigation is based upon this.

THE TEXTURE OF TOBACCO SOIL.

The texture of a soil can be determined very satisfactorily by the method of mechanical analysis which has been described in Bulletin No. 4 of this division. The method consists of separating the particles of soil into grades of different sizes, which are especially distinguished

as sand, silt, and clay, and weighing the quantity of each grade. The texture of a soil controls to a large extent its relation to water and the relative amount of water that it will contain. As a rule, the more clay a soil contains the more water it will hold; for the spaces in the clay soil are so exceedingly small that the water moves very slowly and a relatively large proportion of the rainfall is retained for the use of plants. The texture of the soil, however, does not altogether determine the relative amount of water which the soil will contain, for the arrangement of the soil grains also has a very important influence upon the water content. If the grains are evenly distributed, as in a puddled soil, the soil is much more retentive of moisture than where they are gathered together in flocks or segregated into masses, as in a loamy soil; for when the spaces in the soil between the grains are of nearly uniform size, as they are in a puddled soil, the movement of the water is very much slower than where the spaces are of various sizes, as in a loamy soil. Therefore, while the texture of a soil is a very important factor in the classification of the tobacco lands, the structure, or the arrangement of the soil grains, is also an important factor which must be considered at the same time. The arrangement of the soil grains is not an easy matter to determine, and there is no satisfactory way of expressing the difference in the structure of two soils. It is therefore necessary to determine the texture and to rely upon actual moisture determinations in the soil to determine the structure and the actual relation of the soil to water.

A great many samples of soil and subsoil have been collected from most of the important tobacco districts, and enough of these have been analyzed to enable generalizations to be made as to the character of the soils. Continuous records have been kept for several years of the moisture content of the soils in one or two localities only, in some of the principal tobacco districts. This work should be extended and continuous records kept of the soil condition in a number of places in each district.

SOILS OF THE NORTHERN CIGAR TOBACCO DISTRICTS.

The grade of tobacco used to wrap a cigar for domestic purposes is quite different from that suitable for the filler. Theoretically the wrapper leaves are the best on the plant, the binders are second quality, while all the other leaves are used for filler purposes. The one plant, therefore, is supposed to produce the filler, binder, and wrapper for the complete cigar. As a matter of fact, this is seldom satisfactorily accomplished with the same plant except in Cuba and our Southern States. In the Northern tobacco States a plant which will produce a good wrapper leaf does not, as a rule, make a very good filler. Good domestic wrapper leaf is worth anywhere from four to twenty times as much per pound as a filler leaf, but as the filler leaf is grown on heavier soil, with closer planting, the yield per acre is much larger and, as the cul-

tivation and treatment of the tobacco is less expensive, the return per acre, even at the low price per pound at which it is sold, can be made as profitable as the wrapper.

The Pennsylvania filler is seldom wrapped now with its own leaf. It is wrapped with either a Cuban, Sumatra, Connecticut Valley, or Wisconsin wrapper. A Connecticut wrapper seldom wraps its own leaves, but is used on a Cuban, Pennsylvania, Ohio, or Wisconsin filler. The present prevailing grade in the Connecticut Valley is a wrapper leaf, the second quality being used as binder. In Pennsylvania at the present time the quality is a filler leaf, except on the river lands, where a light, thin-textured leaf is produced, which makes wrappers of a superior quality. The New York lands produce a good type of wrapper, and the crop at present is mainly a wrapper and binder grade. The Ohio tobacco is essentially a filler, and is covered with a Cuban, Sumatra, Connecticut Valley, or Wisconsin wrapper. The tobacco lands of Wisconsin appear to be nearly an average of the other States, and to produce in nearly equal excellence a wrapper and a filler leaf. It is commonly called a binder State.

THE CONNECTICUT VALLEY SOILS.

The tobacco soils of the Connecticut Valley are confined at present to the light, alluvial, sandy terraces and plains bordering the Connecticut River from northern Massachusetts down to within a few miles of the Sound. (See Plates III and IV.) These soils are the general type of the early truck soils of the Atlantic Coast. As a rule the lighter the texture—that is, the less clay they contain—the thinner the texture of the tobacco leaf and the more elastic, pliable and better the wrapper it will make. The yield per acre, however, on these very light soils is very small, and the care necessary to keep the plant growing and to protect it from the occasional drought is expensive; so that there is a limit of profitable production. On these light soils the plant must be kept growing at all hazards, for if the growth is retarded by too great a deficiency of water at any time, the plant will be small and the leaves thick and harsh. With continuous and rapid growth, such as is secured on these soils in favorable seasons, the leaf is of very thin texture, silky, pliable, light-colored, and admirably adapted for a cigar wrapper. Unquestionably some form of irrigation could be profitably adopted on these soils. It is the experience in Florida that if the plant can be kept growing by frequent rains or by judicious irrigation, the maturity of the crop can be greatly hastened; so that the growing season is only about half as long as it would be under unfavorable weather conditions. Every possible means should be taken to secure a continuous growth, and any check, however slight it may seem, must be regarded as a positive injury to the quality of the product if it is to be used as a wrapper leaf. The wrapper should have little body and but little flavor.

The binder is a low-grade wrapper which, from its quality or appearance or both, is not suitable for the outside covering of the cigar.

The filler leaf, being worth much less per pound than the wrapper, is too often neglected in this country, and when cured is but little better than dried leaves or has a very rank, strong flavor. This is a very great mistake, as the filler, forming the main bulk of the cigar, should give it character and flavor. Too much care and attention could not be given to the growing and fermenting of the filler leaf, were it not for the fact that the market demands a good-looking cigar above all else. The quality is a very much smaller factor in determining the market value. The filler should always be a leaf of good body and much stronger and richer in its flavor than the present type of wrapper. The rich, heavy clay soils of Pennsylvania and Ohio are admirably adapted to produce a rich, heavy filler leaf. Unfortunately, the methods of curing and fermentation are not so controlled as to develop the best quality of the leaf, as is done in Cuba.

The accompanying table gives the average results of the mechanical analyses, showing the texture of a number of subsoils of the Northern cigar tobacco lands:

Mechanical analyses of subsoils.

No. of samples.	District.	Principal grade of leaf produced at the present time.	Moisture in air-dry sample.		Organic matter.	Gravel (2-1 mm.).		Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
			P. ct.	P. ct.		P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
9	Connecticut ...	Wrapper and binder.	0.76	2.53		1.03	3.26	9.92	22.62	45.47	10.41	1.36	2.32	
5	Massachusetts.....do.....		.61	2.20		.00	.04	.71	10.09	49.26	30.89	2.71	3.31	
10	New York.....do.....		1.06	2.82		1.94	2.80	9.02	24.47	32.52	15.09	3.09	7.43	
5	Pennsylvania ^ado.....		2.03	3.23		.67	1.23	5.87	6.62	37.18	23.41	5.21	13.80	
10	Wisconsin.....do.....	Binder.	4.70	2.93		.59	1.09	4.98	10.34	15.68	31.04	6.01	22.76	
4	Ohio.....do.....	Filler.	3.05	2.67		.39	.76	2.25	5.04	15.36	37.60	6.41	27.52	
6	Pennsylvania ^bdo.....		3.61	4.47		.68	.78	.91	2.47	13.89	34.23	9.79	29.27	

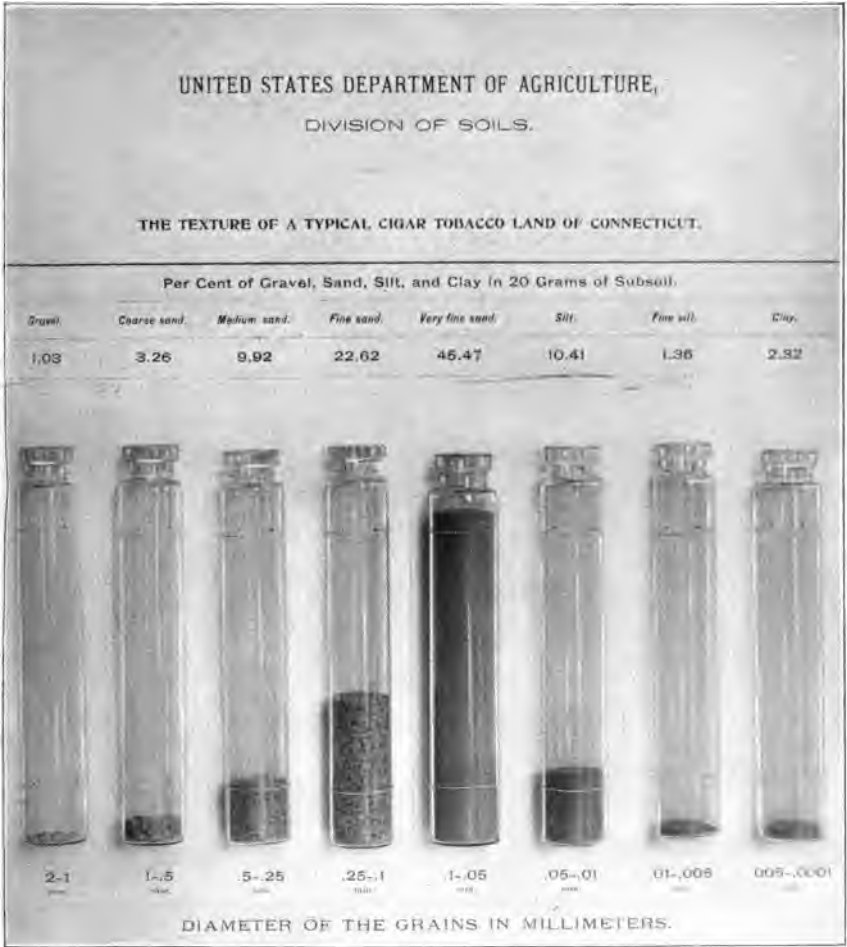
^a River land and shaly limestone.

^b Trenton limestone.

It will be seen from the table that the tobacco soils of the Connecticut Valley, both in Massachusetts and in Connecticut, contain on the average considerably less than 5 per cent of clay. These soils are too light in texture for any of the staple farm crops. They are adapted to the quick-growing spring vegetables, but are not used to any great extent for these crops, except immediately around the cities and larger towns. The conditions seem to be peculiarly adapted to this particular grade of wrapper leaf tobacco.

FASHION AS A FACTOR IN THE VALUE OF TOBACCO SOILS.

It must not be forgotten, however, that fashion has much to do in the consumption of cigars. Just at present the demand is for light wrappers and mild-smoking cigars. A few years ago the demand was for heavier cigars, and these light soils of Connecticut had little or no



UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS.

THE TEXTURE OF A TYPICAL CIGAR TOBACCO LAND OF MASSACHUSETTS.

Per Cent of Gravel, Sand, Silt, and Clay in 20 Grams of Subsoil.

Gravel.	C coarse sand.	Medium sand.	Fine sand.	Very fine sand	Silt.	Fine silt.	Clay.
0.00	0.04	0.71	10.09	49.26	30.89	2.71	3.31

2-1	1-.5	.5-.25	.25-.1	.1-.05	.05-.01	.01-.005	.005-.0001
-----	------	--------	--------	--------	---------	----------	------------

DIAMETER OF THE GRAINS IN MILLIMETERS.

value then for tobacco and were lying out as waste land. At that time the tobacco was grown mainly on the heavier soils and on the "meadow lands" of the Connecticut Valley. Strangely enough, there is little or no difference in the texture of these meadow soils compared with the light, sandy soils now used for tobacco, except that they usually contain a larger proportion of silt.

They are, however, probably by reason of their structure, very retentive of moisture and contain upwards of from 23 to 27 per cent of moisture, while the finest types of tobacco land in the Connecticut Valley contain only about 7 per cent. These meadow soils are therefore not used for tobacco at present, but if in the course of events the style should change and dark wrappers come into vogue, these lands will again be taken up and the present tobacco lands will have to be abandoned or used for other crops.

PENNSYLVANIA - CIGAR TOBACCO LANDS.

The tobacco soils of Pennsylvania are confined mainly to the comparatively narrow belt bordering the Susquehanna River and to the broad expanse of limestone soils typically developed in York and Lancaster counties.

The better class of tobacco lands in Pennsylvania, and those which produce by far the finest wrapper leaf, are the light, alluvial soils along the river, many of them similar in texture to the tobacco soils of the Connecticut Valley. The main crop, however, of the Pennsylvania tobacco has been grown on the limestone soils of York and Lancaster counties. This is a continuation of the great limestone valley extending down through Maryland and Virginia and to the great area of the Trenton limestone formation in Ohio and Kentucky, forming the great blue grass region of these States upon which the white burley tobacco is at present grown.

This limestone soil, as it is exposed in the tobacco districts of Pennsylvania, is a strong clay soil, well adapted to grass, wheat, and corn. It forms one of the most productive areas in the State of Pennsylvania, and in this respect it is markedly different from the tobacco lands of the Connecticut Valley. There is considerable variety in the texture of the soils, as the limestone itself is not pure, but is mixed with shale. The amount of clay, therefore, in these Pennsylvania lands varies from about 13.8 per cent in the river soils and in the very shaly limestone soils to 29.27 per cent on the average in the pure limestone soils. (See Plate V.) The former grade of soils is preferred just at present to the very heavy ones, as they produce a better grade of wrapper leaf. By proper cultivation, close planting, and especially by proper fermentation and grading of the leaf, the quality of the filler grown on the heavy limestone soils could unquestionably be greatly improved.

It has not been feasible for agents of this division personally to examine the soils of the tobacco districts of New York. (See Plate VI.) A large number of soil samples were collected, however, through rep-

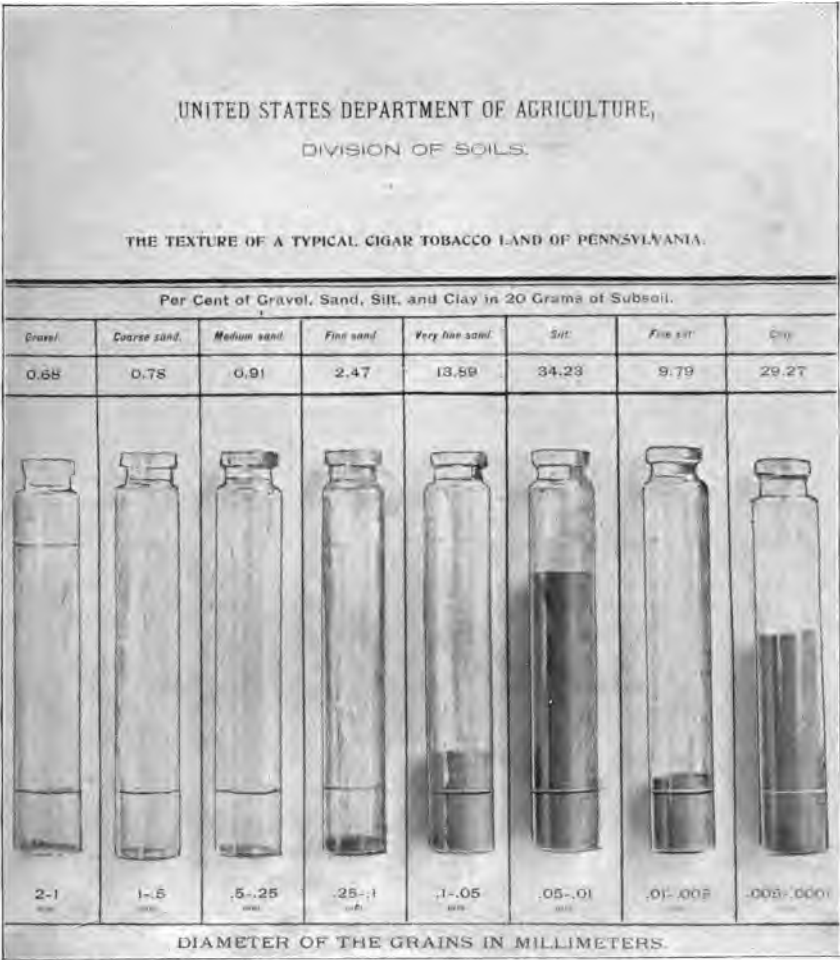
representative growers, whose names were furnished by the Tobacco Growers' Association. The samples were accompanied by full notes upon the character of the soil, the native vegetation, and the quality of the tobacco grown. A number of these soils have been analyzed, and the results show on the average that the soils contain rather more clay than the soils of the Connecticut Valley. They are much lighter in texture than the Pennsylvania tobacco soils.

OHIO CIGAR TOBACCO LANDS.

The cigar tobacco district of Ohio is situated in the southwestern part of the State and includes the country bordering the Miami River, Montgomery, Darke, and Preble counties forming the center of the district. The Miami Valley, in the tobacco area, is from 2 to 5 miles wide, level, and extremely fertile. Bordering the valley are upland rolling hills. Broad terraces extend back from the river in a number of places, giving second bottoms, beyond which come the great rolling red lands upon which tobacco is raised with great success. These soils are well drained, with numerous streams flowing out from between hills. Farther back on the level prairies the land is inclined to be wet and needs thorough underdrainage to be profitably cropped. Throughout the whole tobacco area, underdrainage is practiced to a large extent.

The soil is derived from drift material which has been worked over and modified by subsequent action of water. (See Plate VII.) The underlying rock is the Lower Silurian limestone shale, but it forms no feature of the surface, as it is covered by the drift material. There is quite a variety in the character of the soil, owing to the heterogeneous nature of the material from which it has been derived. The bottom soils are, as a rule, much lighter in character than the upland soils. The second and third bottoms, in cases where they occur, are level terraces. The soils vary much, the black prairie soil and the red silty soil predominating. The soils of the rolling uplands are more uniform in character. The timber is mainly sugar tree, and on this sugar-tree land the finest type of tobacco is produced. The sugar-tree soil is a thin, uniform, silty soil, with red clay or silty subsoil. The lower levels of this upland contain considerable areas of black land, which is considered the best land in the district for general agricultural purposes, but which produce too heavy a leaf and one of poor flavor, so that it is not desirable for tobacco culture. Wheat, corn, hay, and tobacco constitute the staple crops of the district, although on the sandy river lands truck and fruit growing are carried on to a large extent.

Three types of cigar leaf are raised in this district. The most popular at present is the Zimmer Spanish. This has small leaves about 12 inches long, of very fine texture and flavor. It produces about 1,000 pounds per acre. The old Ohio seed leaf is a very large, heavy leaf, 20 inches or more in length, and produces from 1,500 to 2,000 pounds per acre. This is little grown in the district at the present time. The



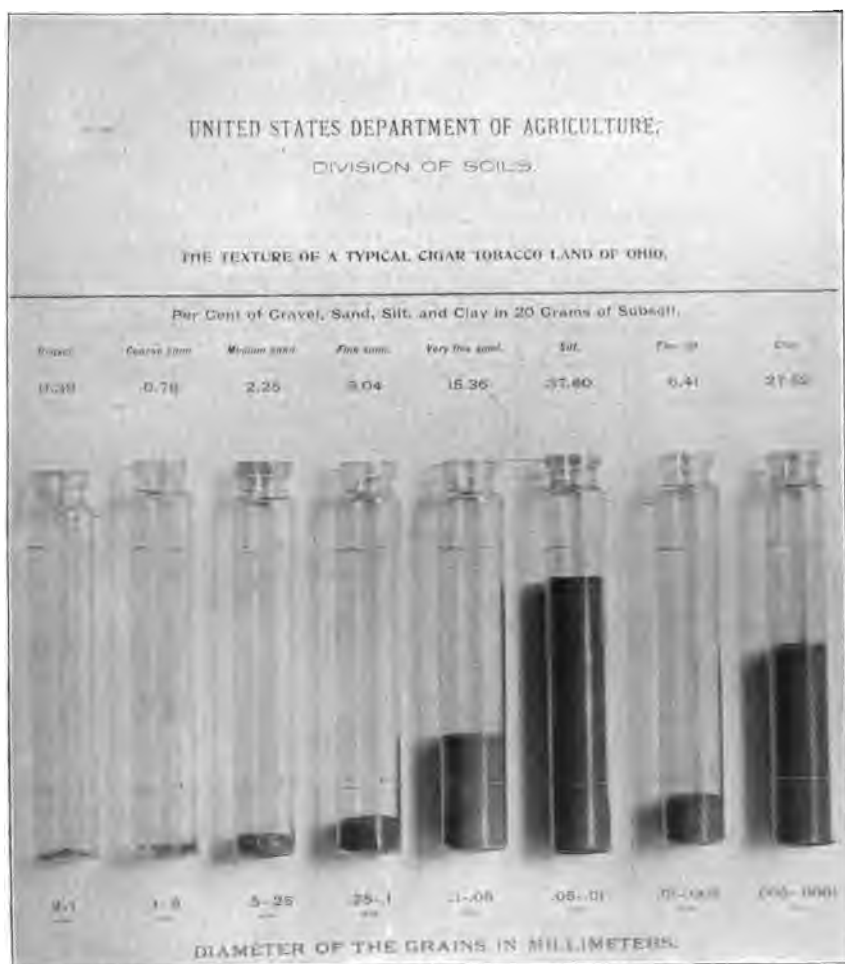
UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS.

THE TEXTURE OF A TYPICAL CIGAR TOBACCO LAND OF NEW YORK.

Per Cent of Gravel, Sand, Silt, and Clay in 20 Grams of Subsoil.

Gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Fine silt.	Clay.
1.94	2.80	9.02	24.47	32.52	15.09	3.09	7.43
							
2-1 mm	1-.5 mm	.5-.25 mm	.25-.1 mm	.1-.05 mm	.05-.01 mm	.01-.005 mm	.005-.0001 mm

DIAMETER OF THE GRAINS IN MILLIMETERS.



Little Dutch has a thick, short, narrow leaf which produces about 1,200 pounds per acre and was at one time very extensively grown. These tobaccos are grown almost exclusively for filler purposes.

It will be seen from the table already given that these soils have a large percentage of clay.

WISCONSIN TOBACCO SOILS.

The Wisconsin tobacco is used both as a wrapper and filler leaf to some extent, but it is known in the markets as a binder State. The character of the leaf is midway between the Connecticut wrapper and the Pennsylvania filler.

The tobacco is grown in the southern part of the State on the prairies and oak openings. The prairies are a dark, rich loam, resting on a rather heavy silt or clay. The oak openings have a loam lighter in color but about the same in texture. Both are gently rolling and, as a rule, have good surface and under drainage. In texture the Wisconsin lands come between the Connecticut and the heavier limestone soils of Pennsylvania. (See Plate VIII.)

SOILS OF THE SOUTHERN CIGAR TOBACCO DISTRICTS.

Tobacco has been grown for many years in Florida, especially in the western part of the State. The tobacco grown there is mainly the Cuban type of cigar wrapper and filler, with some Sumatra lately introduced. The recent scarcity of Habana tobacco has given a great impetus to the cultivation of the crop in Florida, and very extensive arrangements have been made to introduce it to a large extent in the central part of the peninsula.

The accompanying table gives the average texture of the cigar tobacco soils of the Southern States:

Mechanical analyses of subsoils.

Number of samples.	Locality.	Grade of leaf.	Moisture in air-dry sample.		Organic matter.	Gravel (2-1 mm.)	Coarse sand (1-0.5 mm.)		Medium sand (0.5-0.25 mm.)	Fine sand (0.25-0.1 mm.)	Very fine sand (0.1-0.05 mm.)	Silt (0.05-0.01 mm.)	Fine silt (0.01-0.005 mm.)	Clay (0.005-0.0001 mm.)
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
29	Florida, peninsula	Main-crop wrapper, binder filler. Sucker-crop filler.	0.62	1.73	0.26	2.60	18.94	51.53	18.95	1.33	0.59	3.21		
4	Florida, Gadsden County.	Same grades as...	.58	2.68	.68	4.85	20.03	45.53	14.93	4.15	.80	5.15		
4	do.....	Same grades, subsoil.	1.18	5.69	.54	1.94	8.81	35.15	13.39	3.37	1.07	29.30		
3	Texas	Same grades....	.23	.46	1.63	6.52	24.55	37.05	14.16	8.90	1.59	4.70		
1	California	Wrapper and filler.	1.28	3.91	2.94	5.49	19.44	27.33	12.85	13.37	2.18	10.77		
8	Sumatra	Wrapper	7.48	15.41	1.41	4.39	9.95	16.15	17.17	19.11	4.35	5.00		
6	Cuba (Vuelta Abajo).	Wrapper and filler.	.74	3.80	4.06	4.62	8.28	21.67	43.09	6.53	1.82	5.69		
4	Cuba (Remedios).	Same, heavier...	5.17	10.01	1.31	.36	.52	4.51	14.97	21.24	9.37	32.32		

α A light loam, averaging 12 to 18 inches deep, overlying the red clay.

CIGAR TOBACCO SOILS OF WESTERN FLORIDA.

The soils of the older Gadsden County district in the western part of the State are very different from any others which occur in Florida. They are the characteristic "red-land" soil of the Lafayette formation, similar to those found at Wedgefield and Aiken, S. C., which extend south through Georgia and form some of the western counties of Florida, with Quincy as a center. The soil is a light loam resting on a very strong red clay. The clay is exposed in all cuts and in the washings of the land, and is usually found from 8 to 18 inches below the surface. The country is quite rolling, well wooded with hard-wood trees, and in the early spring it has the fresh green appearance of the country in the Valley of Virginia and in the tobacco area of Pennsylvania.

Both the Cuban and Sumatra types of tobacco are grown here, and both are used for wrappers as well as fillers. Unlike the imported Sumatra tobacco, the tobacco grown in Florida from Sumatra seed loses much of its bitter taste, while the sucker crop and inferior leaves are cured up with more body and are much better adapted to filler purposes.

A single plantation in Gadsden County had last year 900 acres in tobacco and, with the crops bought of the farmers in the surrounding country, the company owning the plantation cured and packed upward of 2,500 bales. The season is so long that two crops of tobacco can be produced in the same year, or two or three sucker crops can be grown after the main cutting has been taken. The sucker crop is stronger, heavier, and darker, and is used only as a filler.

It will be seen from the table that these red subsoils contain about 30 per cent of clay, and therefore compare in texture with the soils of the Ohio seed leaf district and with the stronger soils of Pennsylvania. The top soil, however, is quite a light loam, and the character of the land as a tobacco soil depends largely upon the depth and character of the red-clay subsoil. These lands are notable in another respect, which seems to be characteristic of this formation generally, namely, they maintain on an average only about 8 or 10 per cent of moisture against 20 to 22 per cent maintained by the Pennsylvania and the Ohio lands.

CIGAR TOBACCO SOILS OF THE FLORIDA PENINSULA.

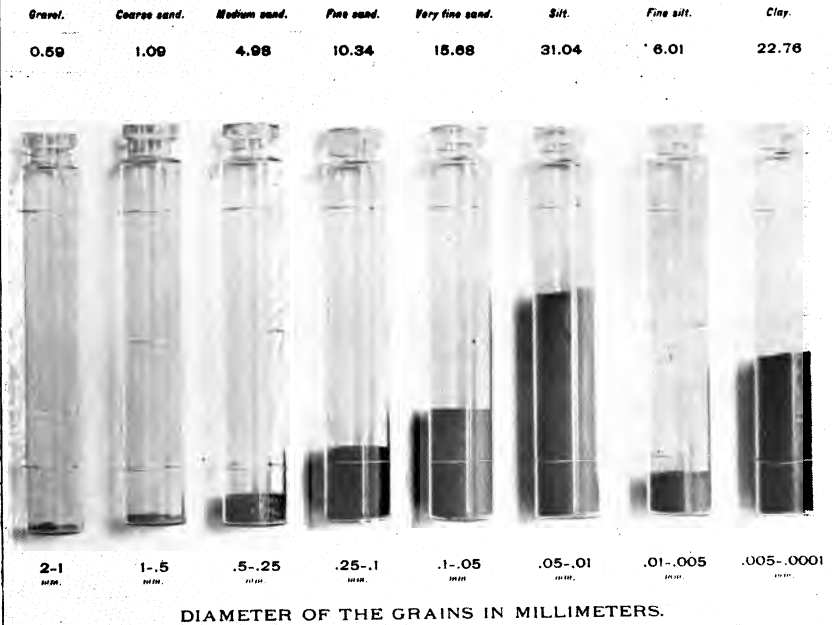
Outside of this area in western Florida most important developments have recently been made around Ocala, Bartow, and Fort Meade. At Fort Meade particularly there is a well-organized company, managed by Cubans, with a large area in tobacco. The first crop was made last year. This was cured and fermented according to the Cuban processes, and without waiting to mellow with age, as is necessary to bring out the finest qualities of a tobacco, the crop was sold at Tampa for a very satisfactory price.

Tobacco growing on the peninsula is essentially a new industry, and comparatively little experience has been available except what has

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS.

THE TEXTURE OF A TYPICAL CIGAR TOBACCO LAND OF WISCONSIN.

Per Cent of Gravel, Sand, Silt, and Clay in 20 Grams of Subsoil.



been collected during the past year. The industry has been developed upon the post-oak lands around Ocala, which are considered the best type of tobacco lands in that locality, and upon the hammock lands at Bartow and Fort Meade. There are large areas of these soils in the State which can be developed through the tobacco interest, and there is every reason to believe that the venture will be very successful. There is no reason to doubt that many of the pine lands are well suited to tobacco.

There is very little difference in the texture of the post-oak lands, the hammock lands at Fort Meade, and the pine lands. The difference in the soil which causes the distribution in the forest growth appears to be mainly due to the difference in the water content of the soils, as will be explained in another place. The soils are all very light and sandy. It will be seen from the table that they contain on an average less than 4 per cent of clay and less than 6 per cent of silt, fine silt, and clay. They contain over 50 per cent of "fine sand," so that they are relatively rather coarse and open. Notwithstanding this open texture, the hammock soil at Fort Meade contains on an average about 8 per cent of water throughout the season, which is about as much as the tobacco lands of the Connecticut Valley contain. This water content, moreover, is for some reason more uniform, and the land can go for some time without rain with no serious injury to the crops. Nevertheless, the planters have been greatly benefited by judicious systems of irrigation through overhead sprays. By thus keeping the plants continually and rapidly growing the crop will mature in forty-five days from the time the plants are set out. On account of the length of the season tobacco can be grown almost continually through the year, and crops can be set out almost every month in the year. Usually two or three crops are made and two or three sucker crops are produced. There is undoubtedly a vast area of land in Florida suited to tobacco, and the climate is unquestionably favorable for the production of a very fine quality of leaf. A very intelligent method of growing and fermenting is being practiced, and there is no reason why the industry should not be successful.

For a great commercial success there must be a large quantity of tobacco for the manufacturers to depend on in maintaining particular brands of cigars. The method of curing and sweating can be more economically and successfully done in large bulk than in small quantities. The experience of the growers in Cuba and Sumatra, that the tobacco grown near the water has an inferior burn, must be given due consideration in extending the industry toward the coast and developing it in the lake regions of the State.

It has not been feasible for agents of the Department to make a personal investigation of the soils of the new tobacco districts which are being developed in Texas and in southern California. A number of samples of soil have been received from prominent growers from both

States and have been analyzed in the Division. The results as given in the table show that the soils agree very well with the finer grade of cigar tobacco lands. The general climatic conditions, however, are different, and great care and judgment should be used in selecting suitable locations for the industry.

BRIGHT TOBACCO LANDS.

The bright yellow tobacco used for cigarettes, plug wrappers, fillers, and cutting is grown mainly in Virginia, North Carolina, South Carolina, and East Tennessee. (See Plate IX.) It is, however, produced in smaller quantities in several of the other Southern States. Wherever it is grown the industry is confined to a certain type of soil. The conditions in Granville and Buncombe counties, N. C., and around Danville, Va., are typical of the conditions upon which the industry is based.

The typical bright tobacco land consists of a loose, porous sand, containing not more than 8 or 10 per cent of clay. This sand must be at least 12 inches deep. Many areas are cultivated in which the sand extends to a depth of 5 or 10 feet or more, and a very fine quality of tobacco is produced. As a general rule the less clay the soil contains and the deeper the sand the finer the quality of the tobacco, providing it keeps growing continuously. The trouble with such very light soils is that they produce but a small yield per acre and there is danger of drought, which would check the growth of the plant and cause the leaves to thicken. It is for this reason, therefore, that it is preferred to have the sand underlaid at a depth of 18 to 22 inches by a heavier clay, which tends to conserve the moisture supply of the soil and renders the plant less subject to the injurious effects of what would otherwise prove a severe drought.

The clay which underlies the bright tobacco lands of Virginia and North Carolina is the same as that upon which the heavy manufacturing and export tobacco is grown. Where this clay is exposed to the surface the heavy type of tobacco is produced; where it is covered from 12 to 20 inches with fine-grained sand the bright tobacco is produced the most profitably.

The country throughout these regions is generally quite rolling, with numerous "draws," or natural ditches, and streams, so that the land is well drained. The sandy covering is usually found on the ridges or slightly elevated plateaus, while the heavy clay may be exposed within a few feet, and the two types of tobacco successfully grown upon the same farm. For this reason it has never been easy to define the areas of the two types of tobacco, for they are both grown in the same counties and frequently on the same farm.

The accompanying table shows an average of 44 samples of the subsoils of the bright tobacco lands which have been examined, and they contain about 8 per cent of clay. This is quite uniform, the extreme range for profitable tobacco culture being probably between 6 and 12

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS.

THE TEXTURE OF A TYPICAL BRIGHT TOBACCO LAND OF VIRGINIA AND NORTH CAROLINA.

Per Cent of Gravel, Sand, Silt, and Clay in 20 Grams of Subsoil.



DIAMETER OF THE GRAINS IN MILLIMETERS.

per cent. The character of the red clay subsoil is also shown for the manufacturing tobacco district of Virginia:

Mechanical analyses of subsoils.

Number of samples.	Locality.	Description.	Moisture in air-dry sample.		Organic matter.	Gravel (2-1 mm.).	Coarse sand (1-0.5 mm.).		Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).		Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Finesilt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
			P. ct.	P. ct.		P. ct.	P. ct.	P. ct.		P. ct.	P. ct.		P. ct.	P. ct.	P. ct.
44	Virginia and North Carolina.	Bright yellow...	1.10	2.24		2.57	6.39	13.67		22.02	23.45	14.08		5.43	8.23
55	Kentucky and Tennessee.	Export	2.23	3.00		.39	.56	.73		1.93	9.50	52.50		6.28	22.59
30	Kentucky and Ohio.	White burley...	3.48	4.42		.64	1.63	1.44		1.22	7.04	39.77		9.36	31.62
21	Virginia	Manufacturing .	5.55	7.87		1.22	2.05	3.47		6.94	9.45	11.29		7.67	44.38

As the relation of the physical properties of the soil is not thoroughly understood or practically recognized by the growers, a large amount of land is now cultivated in bright tobacco which is not suited to this plant and which does not produce a good grade. On the other hand, there are large areas not at present under cultivation which could be developed into very fine tobacco lands. The typical bright tobacco soil is of little value for any of the staple farm crops, although, when suitably located near transportation lines, it is admirably adapted to the production of early vegetables, watermelons, and sweet potatoes.

MANUFACTURING TOBACCO LANDS OF VIRGINIA AND NORTH CAROLINA.

Before the development of the white burley industry the strong red-clay soils around Charlottesville, Lynchburg, and Danville, Va., and in Granville and neighboring counties of North Carolina were extensively used for the production of the typical Virginia manufacturing and export tobacco. These areas are located mainly on the gabbro, gneiss, and Lafayette clays. The material is quite uniform, the subsoils containing from 30 to 50 per cent of clay. (See Plate X.) They are very productive and are well suited to the staple farm crops, such as grass, wheat, and corn. Since the introduction of the White Burley tobacco, however, there has been a very noticeable decrease in the acreage in Virginia, especially of the soil adapted to the heavier types of tobacco, and the cultivation of tobacco on these lands has been almost abandoned. The industry is confined now principally to small areas along rivers, streams, or creeks and upon recent deposits which can not well be referred to any of the older geological formations and which can not well be examined without a detailed examination of the larger part of the State.

The same remark holds true in regard to the tobacco industry in North Carolina. A great change has taken place very recently, and the acreage devoted to the heavier type of tobacco has been considerably reduced. These heavy clay lands are being used for other crops,

and the tobacco is grown upon limited areas in certain districts where the quality of the tobacco produced is such as to make it reasonably profitable. Here, again, it is impossible to make any statement in regard to the tobacco district without making a detailed study of the soils of the State. There seems to be no general type of soil. The tobacco grown upon the soil which was formerly cultivated most extensively is no longer profitable.

The table shows that these soils, which a very few years ago would have been considered the typical manufacturing tobacco land, contain on an average over 40 per cent of clay and have thus a larger content of clay than the soils of any other tobacco district.

THE WHITE BURLEY TOBACCO LANDS OF KENTUCKY AND OHIO.

The white burley tobacco is confined to the well-marked type of soil of the Lower Silurian limestone in central and north central Kentucky and the adjacent counties of Ohio. This embraces the blue grass region of Kentucky, and it is upon these fine, fertile, blue grass soils that the white burley is grown. (See Plate XI.)

The country has the general appearance of an old limestone region, generally rolling and with frequent depressions, sinks, and caves. The hills, 400 to 500 feet high, bordering the Ohio River and extending from 6 to 10 miles back, are generally steep, and fields are often cultivated in tobacco with slopes as great as 45 degrees. The valleys are narrow, winding, and V-shaped, and no bottom lands are found excepting along the larger rivers and streams. The country back from the hills on the Ohio side is generally rolling. The drainage is excellent.

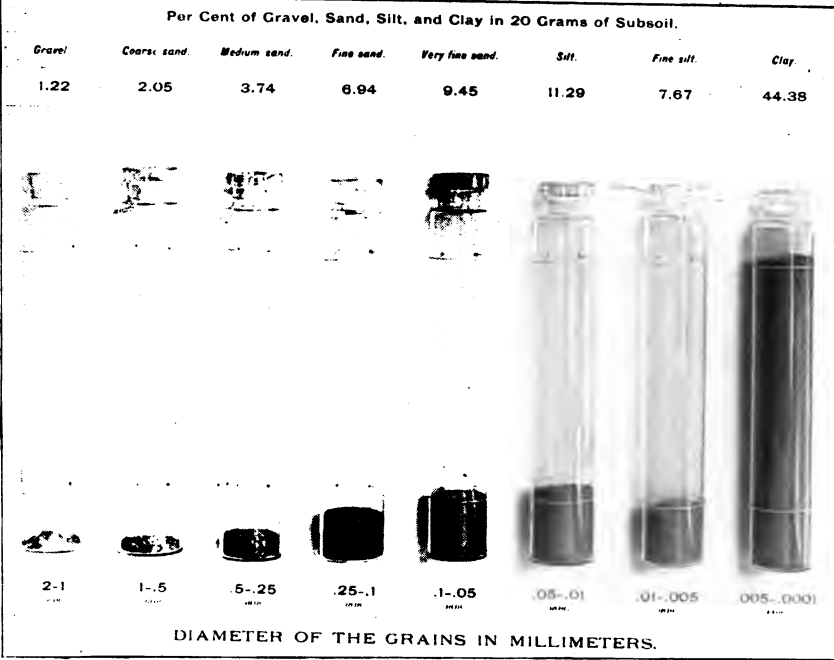
The tobacco lands on the Ohio side are all within the hills on the Ohio River and confined to two kinds of soil, popularly known as the "sugar-tree land" and "beech land." The beech lands lie low in the valley and are inclined to be wet, and do not produce the finest quality of leaf. The sugar-tree lands lie well up in the valleys and are considered the typical white burley soil. Back from the hills, in Ohio, the soil becomes white, wet, and "crawfishy" and does not produce a fine quality of burley. These flat lands are of drift origin, timbered with white oak, and usually need to be underdrained in order to produce well.

In Kentucky the tobacco area is confined to the Trenton and Hudson River limestones. Phosphatic limestone is frequently met with, while chert occurs only sparingly through the area.

The soils are all heavy clay of a uniform deep red color. The depth of the soil varies considerably, the rocks outcropping in many places, especially on the hillsides. Around Lexington the rock is on the average about 6 feet below the surface, while in the northern counties it is at a greater depth than this. The top soil is of light, loamy character, not inclined to form into clods when properly cultivated. The soil is adapted to grass, wheat, and corn, and has made famous the world over the blue grass region of Kentucky. It is seen from the table (page 25) that the subsoil contains on an average about 30 per cent of clay.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS.

THE TEXTURE OF A TYPICAL MANUFACTURING TOBACCO LAND OF VIRGINIA.

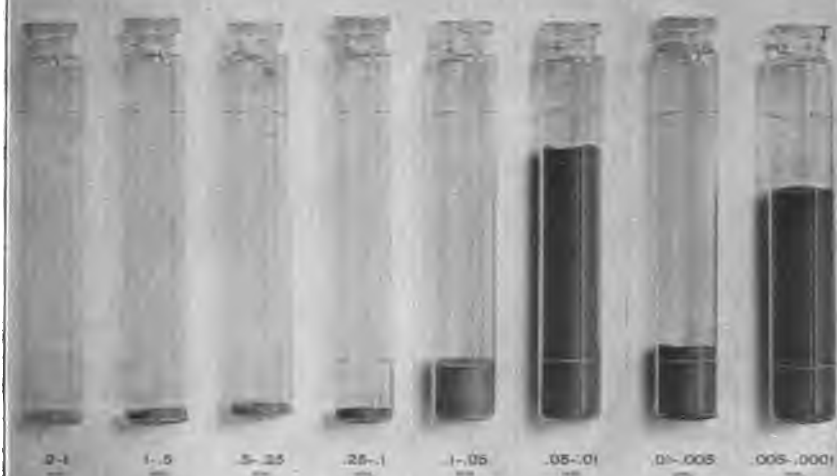


UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS.

THE TEXTURE OF A TYPICAL BURLEY TOBACCO LAND OF KENTUCKY AND OHIO.

Per Cent of Gravel, Sand, Silt, and Clay in 20 Grams of Subsoil.

Gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Fine silt.	Clay.
0.04	1.83	1.44	1.22	7.04	39.77	9.36	31.62



DIAMETER OF THE GRAINS IN MILLIMETERS.

EXPORT TOBACCO LANDS OF KENTUCKY AND TENNESSEE.

The dark, heavy varieties of tobacco adapted to the export trade are extensively grown in western Kentucky and Tennessee on silty soils which are quite fertile in character. The whole area is divided into a number of districts, such as Clarksville, Hopkinsville, Jackson's Purchase, and the Green River district, but the character of the soil is quite uniform in all of these; the class of tobacco grown is generally the same. In each district the types of tobacco adapted to the foreign markets are grown, the types appearing to depend less upon the character of the soil than upon the character of the season, the cultivation, and curing of the crop.

The general character of the country is level or gently rolling, with broken and hilly country along the large water courses. Much of this land was formerly devoid of forest growth and called barrens. It was a prairie region, with trees only along the water courses, and prairie fires are supposed to have annually swept over the country. Since the country has become settled and the large fires prevented, a luxuriant forest growth of hickory and oak has covered the land. The soils are classed by Safford as "rich barrens." The term "barrens" is not to be taken literally to mean poor soil.

The counties of Kentucky bordering the Tennessee line are generally level, with occasional stretches of rugged country along the water courses, but with a soil of quite uniform texture. The southern boundary of the tobacco area is the Cumberland River, while the northern boundary is the carboniferous hills of Kentucky. The tobacco district stretches around these hills, following the subcarboniferous strata as far as the Ohio River on either side.

SOILS ARE HALF SILT.

The soils are mainly derived from the St. Louis group of the subcarboniferous, which are mainly limestone. (See Plate XII.) The disintegrated material is so thick that the rock is seldom exposed, except where the material has been recently eroded. The drainage is excellent, and numerous sinks and caves are found through the country. The soil, whether upland or bottom, level or hilly, is usually of a decided silty character, closely approaching loess in texture. The subsoil has a typical bright red color, which extends to a considerable depth. Where this red color changes to a pale yellow or white, the land becomes crawfishy and can only be profitably cultivated after underdrainage. The lack of color indicates a deficient drainage within recent times and is due to the deoxidation of the iron compound in the decay of organic matters and the absence of sufficient oxygen from other sources to provide for the proper oxidation of the organic matter.

It will be seen from the table that these soils contain on an average about 50 per cent of silt. It ranges from about 40 to 60 per cent, some samples exceeding even this latter figure. With all such silty soils great care has to be taken in their cultivation. They are naturally

quite fertile, but deteriorate very rapidly and excessively unless the fertility is maintained by judicious methods of cultivation and of cropping. Many of these tobacco soils have been run down with constant cropping in tobacco, but some of the worst cases have recently been brought up by rotation with wheat, corn, and clover, together with a judicious application of fertilizers, especially phosphatic manures. The value of careful tillage is becoming more apparent in the whole area, and it is generally recognized now that the quality of the tobacco and the price it brings on the market can be very materially influenced by the kind and condition of the cultivation.

The soils of the Lower Green River district lie within the carboniferous strata along the Green River, and, although these are underlaid with sandstone, the soil proper presents the uniform silty character of the other export tobacco districts.

The Jackson's Purchase region, lying between the Tennessee and Mississippi rivers, is made up mainly of loess and loam, and has the same silty character as the other districts and produces essentially the same type of tobacco.

The accompanying diagram (Plate XIII) illustrates graphically the relative proportion of the sand, silt, and clay in the soil adapted to different classes and types of tobacco, and shows, upon careful study, a marked relation between the texture of the soil and the grade of tobacco produced. A detailed statement of the analyses upon which these summaries are based is given in the table at the end of the bulletin.

THE RELATIVE WATER CONTENT OF TOBACCO SOILS.

It has been stated that a classification can be made of the tobacco soils in accordance with their texture, as this determines to a large extent the water content of the soils and the amount of water at the disposal of the crop. The texture is not the sole factor, however, which determines the water content; so it has been necessary to keep actual records of the water content of some of the principal tobacco soils. Only preliminary work has been started in this, as a satisfactory method for the ready determination of the water content of the soils has only just been completed. So far as these records have been taken they show a very great difference in the soils adapted to the different classes of tobacco, and in a general way agree with the texture of the land.

The earlier records were made by taking a sample of soil in a brass tube, driven from the surface of the ground to a depth of 12 inches. The sample was transported to the laboratory without any evaporation and there dried at a temperature of 110° C. and the amount of water determined by the loss in weight. The investigations this year have been made by the electrical method described in Bulletin No. 6.

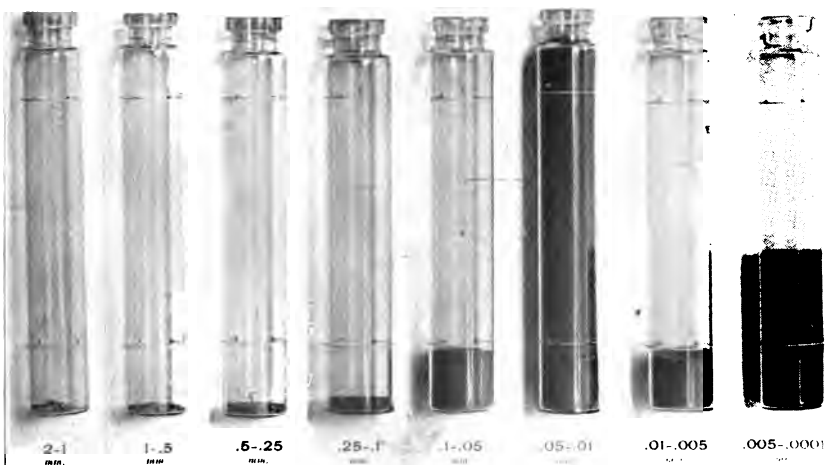
These records must be maintained through a number of years before reliable data can be established to show the average water content of the soils, as well as to show the normal variations which may occur in

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS.

THE TEXTURE OF A TYPICAL EXPORT TOBACCO LAND OF KENTUCKY AND TENNESSEE.

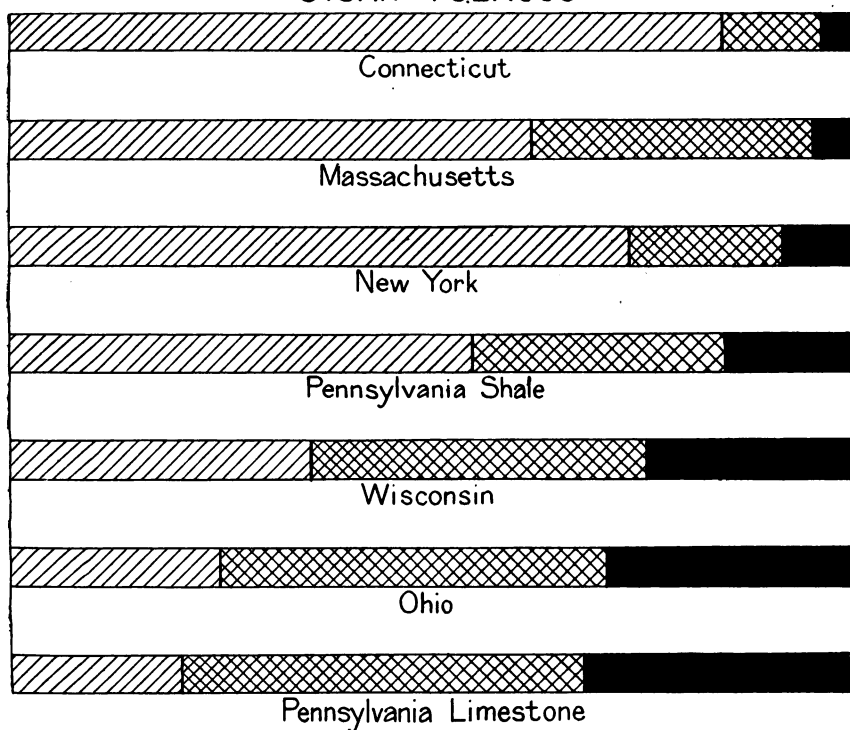
Per Cent of Gravel, Sand, Silt, and Clay in 20 Grams of Subsoil.

<i>Gravel.</i>	<i>Coarse sand.</i>	<i>Medium sand.</i>	<i>Fine sand.</i>	<i>Very fine sand.</i>	<i>Silt.</i>	<i>Fine silt.</i>	<i>Clay.</i>
0.39	0.56	0.73	1.93	9.50	52.50	6.28	22.59

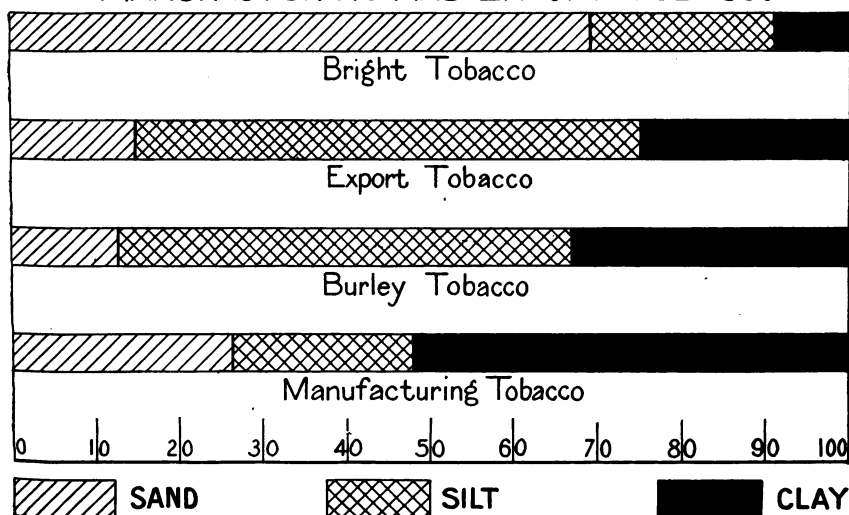


DIAMETER OF THE GRAINS IN MILLIMETERS.

CIGAR TOBACCO



MANUFACTURING AND EXPORT TOBACCO



P. P. F. det.

the water content without danger to the plant. At the same time sufficient work has been done to give an idea of the mean relative water content of these different soils, under the meteorological conditions which have existed. This water content is sensibly the same for several of the soils in any one season.

The amount of water a soil contains depends largely, as has been stated, upon the texture and structure and is influenced of course by the character of the season. It varies from day to day, and these variations are exceedingly important in their effects upon the crop. The term "mean water content," therefore is only to be used as a measure of the relative water-holding capacity of the soil under similar meteorological conditions.

MEAN WATER CONTENT OF THE NORTHERN CIGAR TOBACCO SOILS.

Tobacco soils of the best grade in the Connecticut Valley maintain on an average about 7 per cent of water throughout the season. There are many soils cultivated in tobacco which average 10 or 12 per cent, but these do not produce a tobacco leaf of the finest texture and most desirable quality for the present market. On the other hand, there are soils cultivated in tobacco which maintain less water than this, and while in favorable seasons, when the tobacco is kept constantly growing, they produce a very fine and delicate leaf, it is not on the whole a safe or economical condition under which to grow the plant on account of the small yield per acre and the injury liable to occur in dry seasons. The meadow lands of the Connecticut Valley, which were formerly cultivated in tobacco when a dark, heavy leaf was in demand, contain on an average from 20 to 28 per cent of water. As already stated, these soils are entirely unfit for the production of the grade of tobacco necessary to meet the present market demands.

The tobacco soils of Pennsylvania, as already explained, are heavier than those of the Connecticut Valley and maintain on an average about 18 per cent of water. The present season has been unusually wet, and the average this year has been 4 to 5 per cent higher, but as a result of three years' observations 18 per cent can safely be taken as the mean water content of the average tobacco soil of the limestone area of the Pennsylvania district.

Soils which produce the best wrapper leaf in Pennsylvania are those which have the lightest texture and contain the smallest water content, while the heaviest limestone soils maintain on an average 22 to 23 per cent of water and produce mainly a heavy, strong filler leaf.

The soils of the tobacco district of Ohio are as heavy in texture as the limestone tobacco lands of Pennsylvania. They have maintained on an average the present season rather more than 27 per cent of water. It is probable that the mean water content of these soils in an average season would amount to about 23 to 24 per cent of water. The tobacco grown under these conditions is used almost exclusively as a filler leaf.

No records have been kept of the water content of the tobacco soils of New York or Wisconsin.

It is unquestionably true that the texture of the soil and the meteorological conditions, with the resultant water content, determine to a marked extent the character and grade of leaf which can be produced. In this, as in all other agricultural lines, the aim should be to recognize the conditions and adopt the crop, the method of cultivation or fermentation, and the grade of leaf which those conditions are best adapted to produce. If the general character of the soil in a locality is adapted to the wrapper leaf, use only such soils as may be reasonably expected to give the best wrapper leaf. If, on the contrary, the soils of the district are adapted only to filler leaf, use only such of the soils as are best adapted to this grade and plant, cultivate, manure, and ferment the crop for the specific purpose of producing a filler leaf of superior quality. Most of the tobacco soils of the Northern States will not produce equally good fillers and wrappers.

WATER CONTENT OF THE FLORIDA TOBACCO SOILS.

Records have been kept during the present season of the moisture conditions in the soils of the Gadsden County district of West Florida and of the newer tobacco district of Fort Meade, in the peninsula. The mechanical analyses showed that the tobacco land in western Florida consisted of a light loam about 12 inches deep resting on a heavy red clay which is naturally well drained. The hammock soil of Fort Meade is, on the other hand, a very light sandy soil, extending down to a very considerable depth. Both soils produce a hard wood growth. Strange to say, in spite of the great difference in the texture of the subsoil, the soils of these two localities have maintained during the present season almost identically the same amount of moisture. The average water content of the soil at Fort Meade, for a period of four months, was 8.6 per cent, while the mean water content of the soil at Quincy for the same time was 8.26 per cent. It is a surprising thing to find that these soils maintain about the same amount of water, but this is in line with the general facts that the hammock soils of Florida maintain very much more water than would be expected from their texture, or than is maintained by soils of similar texture further north along the Atlantic Coast. This matter of the relatively large amount of the water content of the hammock soils of Florida will be discussed in a separate bulletin.

No records have been kept of the moisture conditions in the tobacco soils of Texas or of California, and unfortunately none have been kept in the tobacco soils of Sumatra and Cuba.

WATER CONTENT OF THE SOILS OF THE MANUFACTURING AND EXPORT TOBACCO DISTRICTS.

As in the northern cigar tobacco districts, it will be seen that the texture of the soil and the water content appear to determine the type

of tobacco produced. The typical soils for the bright yellow tobacco of Virginia, North Carolina, and East Tennessee maintain on an average about 7 per cent of water. Where the soils contain less than this the leaf is inclined to be thinner in texture and to have a better color, but the yield per acre is small, and the most economical conditions on the whole are maintained by these soils having from 7 to 8 per cent of clay and maintaining on an average about 7 or 8 per cent of water. As the soil becomes heavier in texture and the amount of water increases, other grades and types of tobacco are produced.

The export tobacco lands of Kentucky and Tennessee contain about 22 or 23 per cent of clay, and as a characteristic feature they contain from 40 to 60 per cent of silt. These soils contain on an average about 15 per cent of water, although the soil at Hopkinsville, Ky., this year, which had an unusually wet growing season, maintained on an average about 3 per cent more than this.

The characteristic soil of the limestone area of Kentucky, adapted to the white burley tobacco, as the result of several years' investigation, may be said to maintain on an average about 20 per cent of water. The present season being unusually wet, the water content in the soil at Lexington, Ky., was about 3 per cent above the normal.

Records have not been kept in the manufacturing tobacco soils of Virginia, but from investigations which have been made on adjacent lands it is probable that the mean water content of these soils, having as much as 40 per cent of clay, will not be far from 20 or 22 per cent of moisture.

RECORDS AS A BASIS FOR IRRIGATION.

The object of the daily record of moisture in the soil is not only to determine the average amount soils contain, but to determine the normal as well as the extreme variation. It is known, for example, that in the white burley limestone soil at Lexington, Ky., if the water content is maintained for any length of time above 25 per cent the land will be too wet for crops, while, on the other hand, if it falls to 15 per cent it will be too dry, and anything less than this will constitute a drought. The extent and duration of the drought will be apparent if the results are plotted on cross-section paper. It is possible from such records, therefore, to show the character of a season. The methods of cultivation should have for their prime object the maintenance of the water supply above the line of drought, so that the growth of the plant shall receive no check. If this can not be done by the ordinary method of cultivation, irrigation must be resorted to upon such occasions, if the crop is to be maintained in its best condition.

It will require years to establish satisfactory normals for any soil, but the normal variation which may occur without detriment to the crop can probably be approximately established in a very much shorter time. This line of work is being vigorously pushed now.

TABLES OF THE WATER CONTENT OF TOBACCO SOILS.

Following are the tables showing the records of the water content of tobacco soils so far obtained.

Cigar tobacco land.

POQUONOCK, CONN.

Day.	July, 1895.	Day.	July, 1895.	Day.	July, 1895.	Day.	July, 1895.
	Mois- ture. <i>a</i>		Mois- ture. <i>a</i>		Mois- ture. <i>a</i>		Mois- ture. <i>a</i>
	<i>Per cent.</i>		<i>Per cent.</i>		<i>Per cent.</i>		<i>Per cent.</i>
1.....	8.8	9.....	12.6	17.....	8.8	25.....	8.2
2.....	8.7	10.....	12.4	18.....	8.9	26.....	9.2
3.....	9.0	11.....	11.4	19.....	8.6	27.....	10.1
4.....	9.6	12.....	11.4	20.....	8.5	28.....	10.4
5.....	10.5	13.....	13.4	21.....	8.9	29.....	9.5
6.....	11.1	14.....	14.4	22.....	9.4	30.....	8.9
7.....	11.2	15.....	13.1	23.....	9.6	31.....	8.7
8.....	11.4	16.....	11.1	24.....	8.5		

a At depth 0-12 inches.

WINDSOR, CONN.

Day.	May, 1897. <i>a</i>		June, 1897. <i>a</i>		July, 1897. <i>a</i>		Day.	May, 1897. <i>a</i>		June, 1897. <i>a</i>		Jul. - 1897. <i>a</i>	
	Mois- ture.	Rain.	Mois- ture.	Rain.	Mois- ture.	Rain.		Mois- ture.	Rain.	Mois- ture.	Rain.	Mois- ture.	Rain.
	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>		<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>
1.....			12.1	Trace	13.3		17.....	14.4		10.3		10.2	
2.....			11.6		12.5	Trace	18.....	14.3		10.7	0.13	9.9	
3.....			11.1		12.4	0.01	19.....	14.2		10.6		10.1	0.10
4.....			11.1	Trace	12.3		20.....	14.1		11.6	.33	10.1	
5.....			11.0	0.03	12.0		21.....	16.5	0.32	11.0		11.1	.36
6.....			11.0		11.9		22.....	15.4		10.8		13.3	1.70
7.....			10.8		11.8	.01	23.....	14.8		10.8		13.1	.42
8.....			10.8			Trace	24.....	15.6	.25	10.7		10.5	Trace
9.....			15.3	2.35			25.....	14.9	.92	10.8		10.2	.11
10.....	0.12		10.8	.08			26.....	13.1		10.7			.12
11.....	.07		10.3				27.....	12.2		10.7		10.0	.01
12.....	.42		10.1				28.....	12.4	.21			10.3	.18
13.....	2.17		10.1		13.7	6.27	29.....	12.3		10.6	Trace		1.02
14.....	14.7	.15	10.2	.15	11.0	2.57	30.....	12.2		14.9	.99	10.2	.04
15.....	14.5		10.1	.04	10.4	.05	31.....	13.5	.53			10.0	.18
16.....	14.4		10.3		10.1								

a Determined by the electrical method at depth 3 to 6 inches.

EAST HARTFORD, CONN.

[Light wrappers and binders.]

Day.	May, 1895.	June, 1895.	July, 1895.	August, 1895.	Day.	May, 1895.	June, 1895.	July, 1895.	August, 1895.
	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>		Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1.....		16.6	15.9	13.2	17.....	13.9	15.8	13.8	15.3
2.....		17.5	14.9	12.3	18.....	13.2	15.6	13.5	17.3
3.....		16.2	15.4	11.4	19.....	16.1	15.4	13.1	16.2
4.....		14.8	17.3	10.9	20.....	16.0	15.2	12.9	15.3
5.....		15.2	16.4	10.7	21.....	15.7	15.1	12.9	14.8
6.....		16.4	15.6	10.9	22.....	15.3	14.9	12.9	14.2
7.....		16.8	15.2	16.8	23.....	15.0	14.7	13.2	13.9
8.....	16.4	15.2	15.4	14.4	24.....	15.2	14.0	12.2	13.6
9.....	17.9	15.3	15.6	13.0	25.....	16.0	13.4	11.9	13.4
10.....	17.7	16.2	15.7	13.0	26.....	19.4	13.0	12.3	13.2
11.....	17.1	16.6	15.2	13.4	27.....	16.8	14.9	14.3	13.1
12.....	16.6	15.7	15.7	13.8	28.....	15.9	16.3	13.4	13.1
13.....	15.8	15.3	15.0	13.4	29.....	15.7	17.3	11.0	13.0
14.....	15.4	14.9	15.5	12.8	30.....		16.7	16.2	12.9
15.....	14.9	15.0	14.9	12.2	31.....			14.2	12.9
16.....	16.6	15.6	14.4	13.3					

a At depth 0-12 inches.

EAST HARTFORD, CONN.

[Dark wrappers and binders.]

Day.	May, 1895.	June, 1895.	July, 1895.	August, 1895.	Day.	May, 1895.	June, 1895.	July, 1895.	August, 1895.
	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>		Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>	Mois- ture. <i>a</i>
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1		22.0	26.5	23.0	17	19.7	15.6	24.5	29.0
2		20.5	26.2	24.1	18	19.3	15.3	23.8	29.7
3		19.3	25.7	23.0	19	18.6	15.0	23.4	28.0
4		19.2	25.0	22.9	20	19.7	14.9	22.8	26.7
5		20.7	24.7	22.4	21	20.2	14.7	22.2	25.3
6		20.2	24.3	21.5	22	20.5	14.5	21.4	24.9
7		19.3	23.8	29.0	23	20.2	14.3	20.5	24.5
8	20.8	18.3	23.6	26.8	24	19.7	14.6	20.0	24.2
9	20.7	17.7	24.5	25.0	25	20.0	15.1	19.4	23.7
10	19.9	17.2	24.6	24.7	26	20.3	15.7	19.2	23.3
11	19.7	16.8	24.6	24.9	27	21.9	15.4	19.3	22.7
12	19.4	16.6	24.8	25.9	28	20.6	15.0	19.8	22.3
13	19.7	16.4	25.4	25.5	29	20.1	15.1	23.7	21.9
14	19.9	16.2	25.4	25.0	30	22.7	15.3	26.8	21.5
15	20.1	16.0	25.2	25.5	31	26.1		24.3	
16	20.1	15.8	25.0	24.6					

a At depth 0-12 inches.

LITITZ, PA.

[Fillers.]

Day.	May, 1897. <i>a</i>		June, 1897. <i>a</i>		July, 1897. <i>a</i>		August, 1897. <i>a</i>	
	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.
	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>
1	25.3		17.5		11.2		32.0	
2	34.0	1.20	24.3	0.06	11.3	0.21	23.0	
3	33.7	.04	22.8		11.2		22.6	
4	34.0	.73	22.4	.03	11.3		22.3	
5	33.7	.03	36.1	2.25	11.2		24.3	0.53
6	33.1		34.0		11.2		23.8	.01
7	31.5		32.6		11.2		23.0	
8	29.8		31.2	.03	11.2		22.3	
9	29.4		33.4	.15	10.2		22.3	.01
10	28.6		36.5		10.2		22.6	.05
11	29.2	.22	30.0		9.6		25.3	.81
12	28.8	.16	29.6	.18	9.5	.28	24.3	
13	36.1	1.30	28.4		29.2	1.90	22.8	
14	33.7	.76	28.1	.03	25.8	.03	21.9	
15	35.0	.28	27.0		22.5		21.3	
16	33.4		26.3	.03	19.6		25.0	1.34
17	31.7		24.8		15.7	.04	23.4	
18	29.6		24.8	.10	15.1	.11	22.4	
19	29.4		22.1		28.4	.72	21.9	
20	29.4		20.9	.09	31.3		21.7	.11
21	28.6		17.6		31.5		21.4	
22	30.5	.42	13.4		31.0		21.2	.11
23	29.2		17.9		30.5		21.1	
24	28.4	.27	15.0		25.2		31.0	1.79
25	32.0	.32	13.6		20.8		29.2	.10
26	30.7		13.3	.13	17.5		27.4	.01
27	28.2		11.9		22.6	.24	25.0	
28	28.5		11.2			1.81	24.0	
29			11.2			.30	22.6	
30							21.9	
31	26.4	.24					21.4	

a Determined by the electrical method at depth 3 to 6 inches.

8564—No. 11—3

GERMANTOWN, OHIO.

Day.	May, 1897. <i>a</i>		June, 1897. <i>a</i>		July, 1897. <i>a</i>		August, 1897. <i>a</i>	
	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.
	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>
1.....			26.4				24.6	0.10
2.....					18.2		28.7	.62
3.....			24.7	0.19	18.3		29.0	
4.....			25.2				27.0	
5.....			24.4			Rain.	26.4	
6.....	37.4		23.2		23.4	1.10	25.8	
7.....	36.3				22.9		25.5	
8.....	33.5		31.9	.43	22.4		25.1	
9.....		0.60	30.0		21.6			
10.....	31.9		28.5					
11.....		.70	28.3			.20		
12.....	31.6				20.3			
13.....	29.6		30.8	.45				
14.....	29.6		30.6					
15.....	31.6	.08				.19		
16.....	29.9					.56		
17.....	28.5			.37		.25		
18.....	27.1				30.5			
19.....	25.0			1.02	29.0			
20.....					26.5			
21.....	32.4	.50			34.9			
22.....	33.4				27.7	.86		
23.....	33.6	.40			27.7			
24.....	37.4	.62	18.5		27.7	.21		
25.....	34.5		18.5		27.7	.80		
26.....	32.9		18.5		30.0			
27.....	31.9		18.4		28.4			
28.....	23.0		18.4		28.9			
29.....	31.3		18.3		26.1			
30.....	31.1		18.9		25.4			
31.....	27.0				25.2			

a Determined by the electrical method at depth 3 to 6 inches.

FORT MEADE, FLA.

Day.	May, 1897. <i>a</i>		June, 1897. <i>a</i>		July, 1897. <i>a</i>		Day.	May, 1897. <i>a</i>		June, 1897. <i>a</i>		July, 1897. <i>a</i>	
	Mois- ture.	Rain.	Mois- ture.	Rain.	Mois- ture.	Rain.		Mois- ture.	Rain.	Mois- ture.	Rain.	Mois- ture.	Rain.
	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>		<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>
1.....	10.2	0.12			7.9		17.....			8.8		8.1	
2.....	10.3				7.5	0.28	18.....			7.8		8.7	0.19
3.....	8.3				10.5	1.32	19.....	0.2		8.2	0.17	8.5	
4.....	7.8				8.9		20.....	8.0		8.6	.19	8.1	
5.....	7.6				10.7	.41	21.....	7.9		8.8	.47	7.9	
6.....	7.3				9.3	.04	22.....	7.9		8.5		9.1	.24
7.....	7.0		7.5	0.13	9.2		23.....	7.8		9.0		8.7	
8.....	7.1		7.4		9.2	.15	24.....			8.7		8.4	
9.....	7.0		8.0	.55	10.7	.11	25.....			8.8	.41	10.6	.62
10.....	6.8		9.0		9.2	.07	26.....			9.0		10.7	
11.....	6.8		7.9		10.5	.47	27.....			8.9	.36	8.7	
12.....	13.6	1.30	8.1		11.0	1.96	28.....			8.7		8.8	
13.....	11.4	1.90	8.0		10.8	1.89	29.....			7.4		8.1	
14.....	9.2	.30	10.8	.59	9.7	.14	30.....			7.9		8.8	.32
15.....	11.0	1.05	8.6	.67	8.5		31.....					9.0	.18
16.....	9.7		9.0	.03	9.4	.08							

a Determined by the electrical method at depth 3 to 6 inches.

Bright tobacco land.

OXFORD, N. C.

Day.	May, 1895. <i>a</i>	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>	June, 1896. <i>a</i>		July, 1896. <i>a</i>	
	Moisture.	Moisture.	Moisture.	Moisture.	Moisture.	Rain.	Moisture.	Rain.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>
1.		11.9	13.9	11.0			10.0	
2.		11.4	14.3	10.7			9.6	
3.		10.9	13.1	10.4			9.5	0.30
4.		10.4	12.1	9.7			9.6	
5.		10.1	11.0	9.2			10.4	
6.		10.6	9.9	8.7			12.0	
7.		10.2	8.9	8.6			15.3	.30
8.		9.6	8.1	8.1			17.0	
9.	18.3	8.8	7.4	6.8			17.6	.09
10.	16.7	8.2	6.9	5.7			18.1	
11.	15.4	8.6	6.6	5.1			18.2	
12.	14.4	9.2	6.4	4.6	12.9		17.6	
13.	13.5	8.7	6.0	4.4	12.8	0.60	16.5	
14.	12.7	8.0	5.7	4.0	12.7		15.4	
15.	12.2	7.4	5.5	3.7	12.6		14.4	
16.	11.7	7.3	5.2	3.4	13.0		13.5	
17.	11.3	7.3	5.0	6.7	13.2		13.1	.42
18.	11.1	7.3	4.6	6.9	13.3		13.2	.42
19.	11.0	7.2	4.4	6.2	13.1		13.2	
20.	13.4	6.8	4.2	5.6	11.6		12.8	.09
21.	12.9	5.8	4.1	8.1	10.3		11.5	.12
22.	12.7	4.7	4.2	7.4	10.3		10.2	.02
23.	12.8	4.4	5.3	6.6	11.2	.55	9.0	
24.	12.9	4.4	8.1	5.7	11.9	.20	8.5	
25.	17.0	4.4	11.2	5.4	11.8		8.0	
26.	16.4	4.3	12.1	5.0	11.7		7.8	
27.	15.6	4.3	12.3	4.8	11.6		7.5	
28.	14.8	4.3	11.7	4.5	11.2		7.2	
29.	14.2	4.2	11.1	4.4	10.9		7.0	
30.	13.3	4.2	10.6	4.3	10.7		6.8	
31.	11.8			4.2			6.5	

Day.	August, 1896. <i>a</i>		May, 1897. <i>a</i>		June, 1897. <i>a</i>		July, 1897. <i>a</i>	
	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.
	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>
1.	6.1		9.77		10.4		7.5	0.32
2.	5.7	Trace.	10.07	0.56	9.8		7.4	.05
3.	5.3		9.49	.20	9.0		7.3	
4.	4.8		10.18		9.0	0.55	7.2	.25
5.	4.9		10.18		9.8		7.2	
6.	5.2		9.77	.10	9.0		7.0	
7.	5.4		9.59		9.0		7.0	.08
8.	5.6		9.01		9.0	.07	7.1	
9.	5.7		9.01		9.0		7.1	.02
10.	5.7		8.28		9.0		7.1	
11.	12.9	1.50	8.86	.05	9.0		7.2	
12.	12.1	1.12	10.10	.27	7.8		7.2	2.01
13.	11.0		10.72	.52	7.9		8.9	
14.	10.0		11.04	.85	7.4	.06	8.6	
15.	9.0		10.52		7.4		8.9	
16.	8.1		10.07		7.4		9.0	
17.	7.3		9.77	.05	7.3		9.0	.52
18.	6.8		9.50		7.2		10.4	
19.	6.6		9.33		10.5	.55	10.6	.40
20.	6.3				10.8	.80	10.7	.70
21.	6.2	Trace.			10.4		10.8	.10
22.	6.0				9.7		11.0	.06
23.	5.9				9.0		9.9	
24.	5.4	Trace.	9.01	.11	8.9		9.9	.20
25.	5.0		9.01	.07	9.0		9.5	
26.	4.6		9.01		7.8		9.4	.05
27.	4.2		8.94	.02	7.9	.27	9.2	.03
28.	4.1		8.86		7.8		9.1	.10
29.	4.0		9.01		7.8		9.1	
30.	4.1		8.66		7.6		9.5	
31.	4.3		10.64	.85			11.0	

a At depth 0-12 inches.

Bright tobacco land.

WILSON, N. C.

Day.	June, 1897. <i>a</i>		July, 1897. <i>a</i>		August, 1897. <i>a</i>		Day.	June, 1897. <i>a</i>		July, 1897. <i>a</i>		August, 1897. <i>a</i>	
	Mois- ture.	Rain.	Mois- ture.	Rain.	Mois- ture.	Rain.		Mois- ture.	Rain.	Mois- ture.	Rain.	Mois- ture.	Rain.
	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>		<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>	<i>Per ct.</i>	<i>Inch.</i>
1.....			6.7	0.04	5.8		17.....	13.0		8.3		3.3	
2.....			6.5		5.9		18.....	11.5		7.9	0.06	3.1	
3.....			6.4	.55	5.8		19.....	11.2	0.26	7.6		3.0	
4.....	8.5		7.0		5.6		20.....	10.6	.09	8.9	Rain.	3.0	0.16
5.....	9.3	0.32	6.9		5.5		21.....	9.6		8.8		2.9	
6.....	9.5	.14	6.6		5.3		22.....	8.8		9.1	.38	5.8	1.62
7.....	9.5		6.3	.09	5.2	0.37	23.....	8.2		8.8		5.6	
8.....	9.0	.01	6.1	.60	5.3		24.....	8.0	.22	8.2		5.4	.05
9.....	8.9		6.6		5.1		25.....	7.9	.20	7.8	.46	5.3	
10.....	8.6		6.4		4.9		26.....	7.2		7.2		5.2	
11.....	8.3		6.2	.01	4.8		27.....	7.1		7.1	.26	5.0	
12.....	8.0		6.0	3.73	4.6		28.....	6.9		7.0	.11	5.0	
13.....	7.8		11.3		4.5		29.....	6.9	.04	6.8	.04	4.8	
14.....	7.4		10.6		4.1		30.....	6.8	.02	6.5		4.5	
15.....	7.4		9.8		3.7		31.....			6.2		4.3	
16.....	15.1	2.21	9.0		3.5								

a Determined by the electrical method at depth of 3 to 6 inches.

DANVILLE, VA.

Day.	July, 1895. <i>a</i>		Day.	July, 1895. <i>a</i>		Day.	July, 1895. <i>a</i>	
	Moisture.	Moisture.		Moisture.	Moisture.		Moisture.	Moisture.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
1.....	17.0	11.0	12.....	16.7	8.8	23.....	13.0	12.0
2.....	15.5	10.4	13.....	13.5	8.3	24.....	17.7	10.1
3.....	13.6	9.7	14.....	12.1	7.7	25.....	16.8	8.7
4.....	12.6	9.7	15.....	17.2	7.6	26.....	15.2	7.6
5.....	12.0	9.9	16.....	16.0	11.9	27.....	14.8	6.8
6.....	12.0	10.5	17.....	13.7	14.0	28.....	12.8	6.3
7.....	13.0	11.5	18.....	12.8	12.2	29.....	12.0	5.9
8.....	13.2	12.5	19.....	12.5	8.5	30.....	11.7	5.8
9.....	10.6	11.7	20.....	12.5	8.1	31.....	11.5	5.7
10.....	10.6	10.5	21.....	14.2	15.4			
11.....	16.8	9.7	22.....	13.5	14.2			

a At depth 0-12 inches.

HANOVER, VA.

Day.	June, 1895. <i>a</i>		Day.	June, 1895. <i>a</i>		Day.	June, 1895. <i>a</i>	
	Moisture.	Moisture.		Moisture.	Moisture.		Moisture.	Moisture.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
1.....	9.7	10.0	17.....	7.7	11.5	5.0		
2.....	9.0	10.8	18.....	7.3	10.2	5.0		
3.....	9.8	9.0	19.....	7.1	9.0	5.0		
4.....	11.0	8.1	20.....	7.0	8.4	5.0		
5.....	10.5	7.7	21.....	6.9	8.2	4.9		
6.....	9.9	7.4	22.....	6.8	8.0	4.8		
7.....	9.0	7.2	23.....	6.7	8.0	4.7		
8.....	8.3	7.8	24.....	11.5	8.1	4.2		
9.....	8.4	8.2	25.....	10.0	8.1	4.1		
10.....	9.5	8.5	26.....	8.5	8.0	4.2		
11.....	10.4	8.7	27.....	9.6	8.0	4.3		
12.....	10.3	8.9	28.....	10.6	8.0	4.4		
13.....	10.1	8.5	29.....	9.5	8.0	4.5		
14.....	9.9	8.2	30.....	9.6	8.1	6.0		
15.....	9.0	9.5	31.....		8.0	5.1		
16.....	8.3	12.0						

a At depth 0-12 inches.

Burley tobacco land.

LEXINGTON, KY.

Day.	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>	June, 1896. <i>a</i>		July, 1896. <i>a</i>		August, 1896. <i>a</i>	
	Moisture.	Moisture.	Moisture.	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.
	Per cent.	Per cent.	Per cent.	Per cent.	Inch.	Per cent.	Inch.	Per cent.	Inch.
1	25.6	28.2	26.6	26.0	1.00	23.5		25.3	0.42
2	24.7	27.5	25.4	26.7		23.1		25.0	1.47
3	24.4	26.3	24.3	27.2	1.35	23.2		24.1	
4	24.2	25.2	24.2	27.6		23.8	0.49	24.0	
5	24.1	24.4	24.1	27.7		23.9		24.0	
6	23.9	24.7	27.7	27.8	.75	23.8		24.3	
7	23.8	25.0	26.5	27.7		23.7		25.3	.57
8	23.6	25.6	25.5	27.5	.40	24.0		24.1	
9	23.5	26.3	24.6	27.2	.60	27.9	1.59	25.8	
10	23.3	26.4	24.2	26.8		27.8		24.5	
11	23.1	26.4	23.9	26.7		27.5	.18	24.0	
12	23.1	25.9	23.7	26.7		27.0	.07	24.6	
13	23.3	25.6	23.3	26.7	.03	26.5		22.5	
14	23.5	24.8	22.9	26.8	.01	26.0		22.8	
15	23.8	24.1	22.7	26.9		26.0	.03	22.4	
16	24.1	23.3	22.3	26.0		26.1	.62	22.1	.07
17	24.4	22.7	22.1	24.6	.03	26.1		21.8	
18	24.1	22.1	21.9	23.8		25.6		21.8	
19	23.9	22.0	21.7	23.3		25.5		22.2	
20	24.4	22.8	21.2	23.1		28.4	1.25	22.9	
21	26.3	25.0	20.6	23.0		29.8	2.30	23.5	.19
22	27.2	27.2	19.8	23.4		29.7	1.03	24.2	
23	25.9	28.5	19.3	23.9	.63	29.0	1.02	24.6	.56
24	24.8	29.7	19.4	24.4	.05	28.5	.01	24.9	
25	24.2	29.8	19.5	24.8		27.5		24.0	
26	25.0	29.7	19.9	25.0		26.5		24.9	
27	24.7	29.5	20.7	25.4	1.15	25.0		25.1	.04
28	23.6	27.9	21.5	25.6	.05	22.5		25.7	
29	23.9	27.1	22.8	25.2		22.0		25.8	
30	25.8	26.1	22.5	24.5		23.0		25.0	
31		25.8	23.2			24.6	.56	23.8	

Day.	May, 1897. <i>b</i>		June, 1897. <i>b</i>		July, 1897. <i>b</i>		August, 1897. <i>b</i>	
	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.
	Per cent.	Inch.	Per cent.	Inch.	Per cent.	Inch.	Per cent.	Inch.
1			25.3		17.4	0.04	15.4	0.04
2			24.9	Trace.	17.1	.02	14.1	
3			25.8	0.31	16.5		12.9	
4			25.0	Trace.	16.6		12.0	
5			24.7		16.3	.02	11.8	
6			24.3		16.2	.13	10.3	
7	35.6		23.7	.07	15.8		8.9	
8			23.5		15.5		8.2	
9	32.4	Trace.	22.9		15.2		7.7	.09
10	32.7	0.94	21.5		16.5	.33	7.5	.13
11	32.7	.34	21.6		14.7	.02	7.5	
12	31.5	.43	20.7		16.7	.01	7.3	
13	30.5	.01	19.5		16.3	.03	7.0	
14	29.7	.04	18.4		16.0		6.8	
15	29.5		17.0		15.5		6.9	.10
16	29.1	.05	16.0		18.2	.51	6.7	
17	28.6		20.3	.93	17.8	.01	6.5	
18	28.2		20.8	.51	17.4		6.4	
19	28.0		19.5		16.9	Trace.	6.3	
20	27.3		18.9	.18	16.6	.06	6.2	
21	27.1		18.3		15.9		5.9	
22	26.7		17.7		15.0		21.5	1.69
23	28.4	1.07	17.1	.07	13.5	.45	19.3	
24	28.0	.28	21.0	2.04	15.2	.12	18.1	
25	27.5	Trace.	20.4	.01	15.6	.46	18.4	.24
26	27.3		19.7		19.3		17.8	
27	26.9	Trace.	19.1	Trace.	18.4	.01	16.9	
28	26.9	.21	18.7	Trace.	17.9		16.1	
29	26.7	Trace.	18.3		17.2		15.0	
30	26.2		17.8	.10	16.7	.10	15.0	.33
31	25.8				16.1		14.9	

a At depth 0-12 inches.*b* Determined by the electrical method at depth 3 to 6 inches.

GREENDALE, KY.

Day.	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>	Day.	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>
	Moisture.	Moisture.	Moisture.		Moisture.	Moisture.	Moisture.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1.....	21.4	23.8	26.0	17.....	21.1	19.3	21.9
2.....	22.7	24.7	25.0	18.....	21.1	17.0	21.2
3.....	24.2	23.3	24.4	19.....	22.0	15.5	21.1
4.....	25.6	22.1	24.1	20.....	22.8	16.0	21.0
5.....	26.4	21.1	24.7	21.....	22.5	17.0	20.9
6.....	26.3	20.2	26.2	22.....	21.6	18.3	20.9
7.....	25.6	19.3	25.9	23.....	22.0	19.6	20.9
8.....	24.8	18.8	25.0	24.....	24.7	20.9	21.0
9.....	24.2	17.9	24.8	25.....	24.7	24.2	21.2
10.....	23.8	17.4	24.3	26.....	19.0	26.2	21.1
11.....	23.6	16.5	22.4	27.....	13.6	26.9	21.0
12.....	23.8	16.1	21.5	28.....	12.6	26.7	20.8
13.....	23.5	15.9	22.8	29.....	13.6	26.6	20.7
14.....	25.8	16.0	22.2	30.....	15.6	25.9	20.5
15.....	24.1	18.3	20.8	31.....		25.2	21.5
16.....	22.5	20.6	22.1				

a At depth 0-12 inches.*Export tobacco land.*

HOPKINSVILLE, KY.

Day.	May, 1897. <i>a</i>		June, 1897. <i>a</i>		July, 1897. <i>a</i>		August, 1897. <i>a</i>	
	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.	Moisture.	Rain.
	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>	<i>Per cent.</i>	<i>Inch.</i>
1.....			18.0		18.5		14.2	
2.....			17.8	0.20	18.0		14.1	
3.....			17.6	.15	17.2		13.9	
4.....			17.5		17.0		13.8	
5.....			17.2		18.1	0.23	14.2	0.18
6.....			16.9		18.2	.03	14.6	
7.....			17.2	.15	18.0		14.8	
8.....			17.6		18.8		14.8	.69
9.....			17.3	.02	17.7	.10	15.5	.03
10.....			17.2		17.2	.05	15.2	.65
11.....			17.2		16.8	.05	14.7	.40
12.....			17.2		16.1		14.6	
13.....			17.5		15.9		13.8	
14.....			17.3		15.7		13.7	
15.....	24.3		17.2	.03	13.8	.45	13.6	
16.....	21.3		18.0	.23	13.6		13.4	
17.....	20.8		18.0		13.8		13.4	
18.....	20.1		18.0		14.0		13.3	
19.....	19.2		19.0	.30	14.2	.03	13.3	
20.....	19.0		20.0	.67	14.7	.02	13.3	
21.....	18.9		19.2	.40	14.6	.15	13.3	.02
22.....	18.0		19.0		14.8		13.2	.29
23.....	19.0	0.20	23.8	.45	14.7		13.2	
24.....	18.5		25.4	.01	14.6		13.2	
25.....	18.2		26.8	.02	14.8	.10	13.0	
26.....	17.6		26.5		14.9	.31	12.9	
27.....	17.5	.10	25.4		14.9	.05	12.8	
28.....	17.4		20.1		14.8			
29.....	18.0	.21	18.5	.15	14.8			
30.....	18.5		19.0	.03	14.6			
31.....	18.2				14.3			

a Determined by the electrical method at depth 3 to 6 inches.

NEWSTEAD, KY.

Day.	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>	Day.	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>
	Moisture.	Moisture.	Moisture.		Moisture.	Moisture.	Moisture.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1.....	20.0	22.2	20.9	17.....	15.7	16.0	13.3
2.....	19.8	21.6	20.7	18.....	15.9	16.0	13.2
3.....	19.5	20.2	20.0	19.....	15.9	14.8	13.3
4.....	19.6	18.5	19.3	20.....	15.1	14.5	16.0
5.....	20.0	17.6	18.4	21.....	14.2	14.0	15.2
6.....	20.5	18.3	17.6	22.....	14.5	13.8	14.7
7.....	19.9	20.0	17.0	23.....	15.2	14.8	14.0
8.....	19.3	21.6	16.5	24.....	15.2	18.2	13.3
9.....	17.9	21.9	16.1	25.....	14.7	20.5	12.9
10.....	17.1	21.5	16.7	26.....	14.9	20.3	12.8
11.....	17.1	20.5	16.4	27.....	15.9	20.2	12.8
12.....	17.4	20.2	15.8	28.....	15.3	19.6	13.0
13.....	16.5	19.2	15.2	29.....	15.3	19.2	13.8
14.....	16.5	18.8	15.0	30.....	17.4	20.8	15.0
15.....	17.0	17.8	14.5	31.....	-----	21.6	14.5
16.....	16.3	17.1	13.8				

a At depth 0-12 inches.

Manufacturing tobacco land.

EASTHAM, VA.

Day.	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>	Day.	June, 1895. <i>a</i>	July, 1895. <i>a</i>	August, 1895. <i>a</i>
	Moisture.	Moisture.	Moisture.		Moisture.	Moisture.	Moisture.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1.....			27.1	17.....	23.7	22.4	24.9
2.....		23.4	21.5	18.....	22.1	22.9	24.4
3.....	23.3	22.8	21.0	19.....	21.2	23.4	23.7
4.....	23.1	23.0	20.8	20.....	20.8	23.3	23.3
5.....	22.9	23.4	20.9	21.....	20.8	21.3	22.8
6.....	22.8	21.9	21.2	22.....	21.0	20.2	22.6
7.....	22.7	20.8	22.3	23.....	21.4	19.8	22.0
8.....	22.6	20.6	24.2	24.....	21.6	20.8	21.5
9.....	22.2	23.5	23.5	25.....	21.6	26.2	20.8
10.....	22.1	23.5	22.7	26.....	21.4	25.5	20.4
11.....	23.7	22.4	22.3	27.....	21.3	23.7	20.0
12.....	22.2	21.6	22.1	28.....	21.2	23.8	22.5
13.....	22.5	21.1	22.3	29.....	21.1	25.0	28.4
14.....	25.9	21.2	22.6	30.....	21.0	23.3	-----
15.....	27.3	21.9	23.2	31.....	-----	22.2	-----
16.....	25.7	22.8	24.0				

a At depth 0-12 inches.

TABLES OF MECHANICAL ANALYSES OF SUBSOILS OF PRINCIPAL DISTRICTS.

The following tables give the mechanical analyses of the subsoils of the principal districts:

Cigar tobacco land.

NORTHERN DISTRICTS.

No. sample.	Locality.	Description and depth.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
Massachusetts.												
1039	Hatfield	6-30 inches.....	P. ct. 0.21	P. ct. 1.48	P. ct. 0.00	P. ct. 0.00	P. ct. 2.50	P. ct. 28.11	P. ct. 55.78	P. ct. 10.71	P. ct. 0.63	P. ct. 0.92
1111	Whately	6-18 inches.....	.77	1.84	.00	.20	.30	8.91	69.98	14.35	.93	1.98
1173	Hatfield	8-30 inches.....	.59	2.71	.00	.00	.40	9.00	42.12	38.90	3.07	3.17
875	do	Subsoil.....	.66	2.15	.00	.00	.12	2.31	40.30	40.41	4.15	4.50
901	do	9-30 inches.....	.82	2.90	.00	.00	.21	2.13	38.11	45.09	4.76	5.98
Average.....			.61	2.20	.00	.04	.71	10.09	49.26	30.89	2.71	3.31
Connecticut.												
1066	Poquonock	12-36 inches.....	.41	.76	1.33	7.40	21.80	31.78	32.77	1.74	.45	.19
950	Windsor	11-35 inches.....	.58	1.30	.00	.07	.36	22.52	65.08	7.46	1.01	1.33
1305	Bloomfield	11-12 inches.....	.58	1.39	.40	1.18	4.68	39.87	45.11	3.82	.84	1.63
1277	South Windsor	10 inches.....	.84	2.13	.00	.16	.60	14.93	67.20	10.93	1.16	1.67
831	East Hartford	0-10 inches.....	.76	4.60	.82	5.39	19.51	24.47	28.34	11.88	1.20	2.41
842	do	10-30 inches.....	.46	2.08	1.05	5.03	18.31	25.83	32.11	11.31	1.15	2.51
1254	Poquonock	9-30 inches.....	.56	1.64	3.22	7.53	19.63	23.76	34.50	5.92	.78	2.53
729	East Hartford	do.....	.49	2.05	.09	.30	1.11	9.95	52.47	27.73	3.56	4.00
1303	Wethersfield	10-18 inches.....	2.18	6.85	2.39	2.32	3.26	10.51	51.66	12.94	3.03	4.65
Average.....			.76	2.53	1.03	3.26	9.92	22.62	45.47	10.41	1.36	2.32
New York.												
1357	Fulton.....	11-20 inches.....	.76	1.34	.94	1.33	2.67	14.84	71.28	5.41	.52	1.36
1279	Phoenix.....	18 inches.....	.91	1.71	.81	1.10	7.22	47.39	34.65	3.32	.95	2.58
1286	Butler.....	12-14 inches.....	1.51	5.40	2.60	4.57	18.01	37.71	16.44	6.44	2.43	5.21
1287	do.....	18-20 inches.....	.69	1.82	3.71	5.88	21.66	38.37	15.71	4.80	2.08	5.54
1281	South Granby	6 inches.....	1.21	2.26	.21	.29	.60	4.61	37.26	42.57	4.20	6.13
1353	Lysander.....	Subsoil.....	.93	2.63	2.20	4.17	14.90	23.60	21.21	19.16	3.48	8.05
1285	South Butler	9-10 inches.....	.84	1.89	1.73	2.05	4.41	17.67	39.56	18.08	3.77	10.08
1283	Fayetteville	6-18 inches.....	1.09	3.23	3.11	2.71	6.42	18.41	27.90	20.70	5.92	10.60
1355	Cato.....	9-18 inches.....	1.33	4.05	1.87	2.84	6.09	18.54	35.02	15.33	3.06	12.18
1289	Baldwinsville	Subsoil.....	1.32	3.83	2.21	3.03	8.17	23.58	26.16	15.12	4.51	12.55
Average.....			1.06	2.82	1.94	2.80	9.02	24.47	32.52	15.09	3.09	7.43
Pennsylvania.												
2568	Washington.....	Shaly limestone, 18-36 inches.	1.31	2.40	.13	2.31	21.77	8.92	24.77	21.57	4.41	11.83
2514	Washington, 2 miles east.	Shaly limestone, 12-30 inches.	2.36	3.01	2.55	3.03	3.90	12.20	29.33	22.53	6.96	12.27
2574	Columbia.....	River land, 12-30 inches.	2.26	2.64	.22	.30	1.66	9.18	52.32	13.82	4.50	12.68
2516	Washington.....	Shaly limestone, 12-30 inches.	1.87	2.69	.11	.18	1.37	1.60	42.83	28.43	4.96	16.03
2511	York, 4 miles south-east.	Phyllite.....	2.36	5.40	.36	.33	.65	1.22	36.65	30.68	5.23	16.19
Average.....			2.03	3.23	.67	1.23	5.87	6.62	37.18	23.41	5.21	13.80
2510	York, 9 miles east...	Trenton limestone, 12-30 inches.	3.68	4.17	.57	.80	1.07	1.92	18.83	35.58	10.98	22.47
2570	Wrightsville.....	do.....	4.51	4.62	.88	.92	.96	1.30	17.72	36.82	7.14	23.87
2508	York, 3½ miles east..	Trenton limestone, 12-24 inches.	2.40	3.52	1.06	.94	.67	1.15	12.35	43.64	8.79	25.23
2804	Lititz.....	Trenton limestone, subsoil.	2.85	4.83	1.41	1.38	1.55	4.98	15.54	30.52	5.27	31.96
1360	Marietta.....	Trenton limestone, 9-30 inches.	5.59	4.36	.12	.22	.27	.37	7.48	28.28	16.24	35.80
16	Lititz.....	do.....	2.63	5.30	.06	.40	.93	5.11	11.45	30.55	10.35	36.30
Average.....			3.61	4.47	.68	.78	.91	2.47	13.89	34.23	9.79	29.27

Cigar tobacco land—Continued.
NORTHERN DISTRICTS—Continued.

No. sample.	Locality.	Description and depth.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1 mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
<i>Ohio.</i>												
3090	Miamisburg	Glacial drift, 9-24 inches.	P. ct. 2.49	P. ct. 2.69	P. ct. .15	P. ct. .65	P. ct. 2.18	P. ct. 4.90	P. ct. 13.84	P. ct. 41.49	P. ct. 6.68	P. ct. 25.60
3111	Germantown	Glacial drift, 12-24 inches.	2.58	2.27	.03	.13	.48	.96	11.84	47.81	7.85	26.75
3120	do	do	3.96	3.06	.03	.20	.95	2.50	17.07	40.25	6.08	27.40
3121	do	Glacial drift, 24-36 inches.	3.16	2.68	1.36	2.07	5.38	11.80	18.71	20.86	5.05	30.35
Average			3.05	2.67	.39	.76	2.25	5.04	15.36	37.60	6.41	27.52
<i>Wisconsin.</i>												
1498	Newark	Limestone, 7-18 inches.	1.47	1.87	3.82	5.13	20.11	31.35	9.26	13.13	1.71	11.53
3259	Stoughton, 5½ miles east.	Oak opening, 9-30 inches.	2.98	1.94	.75	2.01	14.87	36.44	10.91	9.58	2.41	18.65
3249	Edgerton, 4 miles west.	Prairie, 12-36 inches	5.57	3.03	.18	.58	2.92	2.98	17.88	37.27	7.62	22.60
3245	Edgerton, 4 miles northwest.	Oak opening, 12-36 inches.	4.26	3.08	.06	.42	2.96	5.51	18.79	35.67	6.74	23.20
3253	Stoughton, 6 miles east.	Oak opening, 12-30 inches.	5.15	3.00	.02	.11	.41	.58	14.98	42.56	8.71	23.30
3257	Stoughton, 4 miles east.	Prairie, 9-33 inches.	6.06	4.24	.05	.09	.45	.84	17.30	39.35	8.46	23.75
3255	Stoughton, 4½ miles east.	Oak opening, 36 inches.	5.20	2.94	.52	.97	4.97	5.15	17.01	33.89	5.73	23.90
3247	Edgerton, 2 miles southwest.	Prairie, 12-36 inches	4.86	3.84	.15	.47	2.13	3.15	19.06	35.35	7.26	24.53
3251	Edgerton, ½ miles northwest.	Oak opening, 9-36 inches.	4.72	2.28	.38	1.06	.76	17.00	14.63	25.99	4.81	27.40
3254	Stoughton, 6 miles east.	Oak opening, 30-39 inches.	6.71	3.05	.00	.02	.18	.35	16.97	37.56	6.63	28.70
Average			4.70	2.93	.59	1.09	4.93	10.94	15.68	31.04	6.01	22.76

SOUTHERN DISTRICTS.

<i>Florida.</i>												
2827	Ocala	Light hammock, 0-9 inches.	0.35	1.16	(a)	1.59	15.63	62.87	15.70	1.25	0.48	0.61
2819	Fort Meade	Gray hammock, 0-30 inches.	1.06	2.50	0.80	3.81	13.77	50.10	24.41	.90	.55	.99
2821	do	Gray hammock, 20-36 inches.	1.03	2.16	.36	1.40	8.30	48.87	35.36	1.00	.52	1.17
2829	Ocala	Light hammock, 24-36 inches.	.30	.65	(a)	1.45	19.63	62.40	11.65	1.80	.62	1.26
2828	do	Light hammock, 9-24 inches.	.22	.75	(a)	1.80	18.25	65.37	10.07	1.20	.55	1.39
2823	Fort Meade	Mulatto hammock, 12-36 inches.	.47	1.43	.70	2.50	14.30	53.00	24.46	.62	.34	1.58
2820	do	Gray hammock, 0-20 inches.	1.39	2.88	.25	1.36	7.76	41.75	41.22	1.22	.70	1.58
2826	do	High pine land, 0-18 inches.	.47	1.60	.10	.65	4.58	47.88	10.90	.58	.23	1.68
2847	Silver Spring	Light hammock, 12-24 inches.	.19	.40	.62	5.57	28.66	52.71	9.84	.38	.20	1.82
2822	Fort Meade	Mulatto hammock, 0-12 inches.	.62	1.53	.78	2.85	14.35	53.51	23.50	.65	.44	2.07
2837	Ocala	Mixed land, 0-12 inches.	.39	1.63	.09	4.07	32.31	44.72	11.10	2.55	.53	2.09
2845	do	Mixed land, soil	.31	1.34	.10	1.95	24.46	60.25	9.59	.42	.19	2.10
2838	do	Mixed land, 12-36 inches.	.06	.49	(a)	3.15	24.94	51.10	13.47	2.33	1.10	2.29
2830	Ocala, one-half mile south.	Light hammock, 0-12 inches.	.49	1.36	(a)	3.07	21.44	55.54	13.30	2.68	1.33	2.39
2841	Ocala, 2 miles south.	Mixed land, 24-36 inches.	.41	1.10	(a)	1.90	13.83	63.70	12.85	2.06	.94	2.48
2825	Fort Meade, 1½ miles south.	High pine land, 20-36 inches.	.48	2.22	.52	3.14	17.23	49.29	23.14	.62	.36	2.62
2824	do	High pine land, 0-20 inches.	1.54	3.02	.52	2.94	16.00	47.95	24.73	.86	.38	2.62
2852	Bartow	High pine land, 0-9 inches.	.81	3.37	.35	2.21	20.83	46.70	21.89	1.24	.41	2.83

a Trace.

a Trace.

Bright tobacco land.

VIRGINIA AND NORTH CAROLINA DISTRICTS.

No. sample.	Locality.	Description and depth.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
2032	Gills Station, Va., 2 miles south	42 inches	0.40	2.09	0.60	8.08	20.66	26.52	25.38	8.24	5.54	2.48
741	Rockymount, N. C.	Soil	.16	1.34	2.85	10.03	20.28	27.00	25.13	6.29	2.38	2.90
751	Lancaster, S. C.	do	.26	2.52	13.68	18.34	23.45	25.73	12.90	7.85	1.80	3.12
746	Oxford, N. C.	do	.18	1.50	2.56	7.89	25.63	23.65	18.70	13.51	3.16	3.33
745	Pitt County, N. C.	do	.36	2.18	.00	9.2	8.93	55.65	15.85	10.44	1.88	4.00
764	Lancaster, S. C.	Subsoil	.00	3.17	6.41	17.48	29.66	17.18	7.14	12.86	2.05	4.05
760	Canton, N. C.	do	.47	2.19	5.28	11.16	14.78	17.83	25.37	16.79	2.04	4.85
757	Cana, N. C.	do	.91	2.58	3.76	3.22	9.55	19.86	27.77	20.60	6.18	4.87
754	Rockymount, N. C.	do	.06	.87	2.97	8.96	17.26	25.14	14.25	40.11	7.73	4.91
744	Cana, N. C.	Soil	.66	3.72	.00	2.47	9.14	19.60	37.28	17.32	4.08	5.98
2047	Boydton, Va., 9 miles east.	6-30 inches	.22	.88	3.79	24.93	26.99	15.71	12.10	7.78	3.01	5.18
1663	Danville, Va., near	do	2.62	.87	7.84	8.01	13.50	19.33	24.28	12.96	4.79	5.74
758	Pitt County, N. C.	Subsoil	.81	2.30	.19	6.47	7.20	50.15	13.92	14.54	5.77	5.86
748	Weaverville, N. C.	Soil	.70	3.64	4.38	6.22	9.42	12.73	28.01	23.25	4.91	5.94
1722	Kentuck, Va., one-half mile south.	4-15 inches	.97	2.85	1.45	5.93	11.91	23.28	26.06	16.01	5.28	6.24
750	Joy, N. C.	Soil	1.10	5.13	5.16	7.85	8.17	13.65	26.90	20.95	4.51	6.27
747	Canton, N. C.	do	1.00	4.52	4.22	8.35	10.60	14.70	32.42	14.23	3.02	6.67
742	Nelson, N. C.	do	.34	1.92	1.02	3.36	9.78	23.31	17.17	17.68	4.46	6.90
1667	Kentuck, Va., 1 mile south.	6-15 inches	.40	2.73	.76	5.01	13.71	23.96	27.31	12.38	5.80	7.00
2049	Boydton, Va., 9 miles east.	6-12 inches	.34	2.11	1.90	7.97	21.90	22.17	21.15	9.95	5.66	7.42
749	Alexander, N. C.	Soil	.46	3.05	3.15	8.50	15.19	15.86	24.67	18.45	4.25	7.90
2028	Gills Station, Va.	18-30 inches	1.25	4.74	1.24	8.56	15.36	14.45	14.65	16.67	15.71	8.24
117	Oxford, N. C., 4 miles west.	12-16 inches	2.07	.15	.71	1.12	7.37	27.90	24.26	22.77	4.20	8.30
2030	Gills Station, Va., 2 miles east	4-16 inches	.38	1.41	1.19	7.63	16.77	21.83	13.20	16.22	13.74	8.59
761	Weaverville, N. C.	Subsoil	.00	2.94	7.30	7.11	9.11	10.55	17.23	31.15	5.84	8.77
763	Joy, N. C.	do	.00	.00	6.37	8.18	10.80	13.59	20.08	23.18	4.78	8.85
762	Alexander, N. C.	do	.00	.00	3.93	7.89	10.87	11.14	15.52	28.08	7.94	8.91
1372	Danville, Va., near	6-20 inches	1.14	1.03	.14	.74	8.07	28.26	32.16	13.95	5.11	9.17
1329	do	6-18 inches	.44	1.98	4.96	6.30	10.55	17.10	29.03	14.99	5.87	0.25
2052	Boydton, Va., 6 miles east.	6-12 inches	.34	2.02	2.01	11.30	21.88	20.52	17.61	9.92	5.30	9.56
1605	Danville, Va., near	6-18 inches	.71	2.40	1.61	2.29	5.57	19.58	33.13	19.16	6.13	10.00
2031	Gills Station, Va., 2 miles south.	16-30 inches	.70	2.40	1.38	8.04	16.36	18.86	19.73	11.83	10.61	10.05
694	Danville, Va., 9 miles north.	4-30 inches	.38	1.74	.24	.76	5.53	27.35	32.73	15.12	5.55	10.43
2068	Lawrenceville, Va., 4 miles east.	6-18 inches	.42	1.66	.22	9.62	21.20	20.63	13.41	15.89	6.38	10.60
2066	Lawrenceville, Va., 5 miles northeast.	6-30 inches	.30	1.57	1.91	9.47	21.75	26.28	14.41	7.42	6.25	11.11
1751	Kentuck, Va., one-half mile south.	15-30 inches	10.21	6.00	.81	3.32	6.23	11.78	23.91	17.32	9.14	11.24
1668	Kentuck, Va., 1 mile south.	do	8.26	9.99	.16	.73	6.92	14.55	25.50	15.67	8.75	11.46
696	Danville, Va., 7 miles north.	4-12 inches	.72	4.60	.64	1.00	6.30	22.53	36.14	12.45	5.28	11.84
2045	Boydton, Va., 10 miles east.	6-20 inches	.74	1.96	.83	8.70	16.96	20.25	20.92	11.58	5.08	12.87
2027	Gills Station, Va.	6-18 inches	.56	2.24	1.66	8.55	18.34	20.05	19.73	11.24	5.16	13.20
753	Hycov, Va.	Subsoil	.72	3.40	.00	.60	1.82	4.69	40.19	31.27	4.84	13.28
789	Danville, Va.	6-18 inches	5.13	2.61	1.14	3.58	11.75	28.96	21.68	6.54	3.62	15.05
1833	Kentuck, Va.	6-30 inches	.96	2.47	1.42	3.31	6.58	16.39	31.05	15.66	5.94	15.98
755	Nelson, N. C.	Subsoil	.56	3.40	1.17	3.31	7.90	18.22	26.49	17.58	4.41	16.58
Average			1.10	2.24	2.57	6.39	13.67	22.02	23.45	14.08	5.43	8.23

Manufacturing tobacco land.

VIRGINIA DISTRICT.

No. sample.	Locality.	Description and depth.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1 mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.001 mm.).
<i>Virginia.</i>												
643	Charlottesville, 2 miles north.	Gabbro, 8-24 inches	<i>P. ct.</i> 2.34	<i>P. ct.</i> 5.16	<i>P. ct.</i> 6.21	<i>P. ct.</i> 0.30	<i>P. ct.</i> 5.62	<i>P. ct.</i> 9.72	<i>P. ct.</i> 12.56	<i>P. ct.</i> 11.55	<i>P. ct.</i> 10.88	<i>P. ct.</i> 30.60
2064	Lawrenceville	Gneiss, subsoil.	2.23	8.68	1.14	4.40	4.86	9.90	20.04	12.41	5.26	31.58
646	Charlottesville, 1 mile northeast.	Gabbro, 9-24 inches	5.65	7.29	.44	.88	.86	.61	4.94	23.89	21.90	34.15
651	Lynchburg	Gneiss, subsoil.	3.94	6.99	1.66	2.87	8.96	18.06	12.77	6.89	2.26	35.06
1665	Danville, 1 mile north.	do	12.33	7.85	.45	.40	1.01	4.16	18.33	15.05	5.70	35.20
2060	Lawrenceville, 4 miles east.	Gneiss, 12-30 inches	2.46	7.41	3.84	5.53	7.09	8.04	16.85	5.49	4.44	39.25
650	Charlottesville, 1 mile west.	Gabbro, 8-16 inches	2.78	6.74	3.84	5.61	5.43	7.73	10.11	8.62	7.74	43.18
658	Forest	Gneiss, subsoil.	8.97	6.68	1.27	1.64	4.77	7.45	7.47	0.20	8.48	44.70
647	Charlottesville, 2½ miles northeast.	Gabbro, subsoil.	8.51	8.49	.06	.17	.19	2.18	5.88	14.83	14.82	44.96
1664	Danville, 3 miles north.	Gneiss, subsoil.	7.80	10.50	.16	.13	.25	.91	2.39	24.78	7.89	45.00
2062	Lawrenceville, 4 miles east.	Gneiss, 12-30 inches	3.21	9.19	.66	1.48	3.82	10.40	18.26	4.43	3.60	45.16
652	Lynchburg, 3 miles south.	Gneiss, subsoil.	3.44	5.63	.35	1.37	5.72	14.73	10.79	6.70	4.62	45.84
654	Lynchburg, 5 miles west.	do	4.01	7.40	.65	4.23	8.48	12.54	8.93	3.82	3.69	47.13
1997	Mossingford	do	2.88	8.82	1.36	2.07	3.85	6.97	11.31	9.88	5.30	47.33
653	Lynchburg, 4 miles south.	do	5.31	7.13	.28	.88	7.34	9.52	5.42	9.48	6.66	48.20
644	Charlottesville	Gabbro, 8-24 inches	9.55	7.67	.56	.44	.83	1.71	5.56	13.49	9.55	50.11
655	Bedford Springs	Gneiss, subsoil.	5.64	8.46	.72	.87	2.05	5.51	7.32	9.91	6.54	52.18
2056	Boydton, 1 mile east.	do	3.56	9.12	.04	.02	.06	.32	6.44	17.84	11.26	52.31
642	Charlottesville, one-half mile northeast.	Gabbro, 8-24 inches	7.28	6.48	.67	.99	1.36	2.55	5.50	13.76	9.82	52.46
659	Forest, one-half mile south.	Gneiss, subsoil.	8.23	9.07	1.02	2.27	4.39	6.96	4.51	5.09	5.94	53.13
656	Bedford Springs, 1 mile north.	do	6.47	10.50	.16	.42	1.53	5.76	4.08	8.92	5.74	54.53
Average			5.55	7.87	1.22	2.05	3.74	6.94	9.45	11.29	7.67	44.38

Burley tobacco land—Lower Silurian (Trenton and Hudson River Limestone).

KENTUCKY AND OHIO DISTRICTS.

<i>Ohio.</i>												
3091	Georgetown, 3 miles east.	12-36 inches	3.24	2.96	0.16	0.93	1.96	2.84	11.31	47.71	6.68	22.25
3087	Aberdeen, 4 miles west.	12-24 inches	3.28	3.67	.20	.37	.48	.80	17.41	33.06	7.78	34.03
3082	Georgetown, 1½ miles southeast.	9-24 inches	4.05	3.46	.02	.09	.13	.42	9.65	34.77	7.70	40.83
3089	Higginsport, 6 miles north.	9-30 inches	4.32	3.98	.01	.03	.10	.45	6.13	32.25	8.35	44.50
<i>Kentucky.</i>												
3072	German town, 2½ miles west.	0-12 inches	2.04	3.83	.02	.58	1.06	1.18	10.12	56.27	9.58	15.58
1101	Mount Sterling	6-18 inches	2.36	3.95	1.52	1.80	1.48	2.40	10.07	42.97	13.39	18.25
1851	Winchester	do	2.48	6.15	.60	1.84	1.77	1.38	3.17	43.26	18.20	22.50
3073	German town, 2½ miles west.	12-30 inches	3.28	2.70	.18	.67	.82	.57	9.46	50.03	8.49	23.50
1853	Winchester	6-18 inches	2.38	4.60	1.59	2.71	2.03	1.36	2.74	44.61	14.39	24.75
2585	Lexington, 10 miles southeast.	6-24 inches	3.08	3.69	1.73	2.66	1.90	1.13	5.36	45.76	9.47	25.71
1991	Greendale	13-25 inches	2.22	4.68	.98	1.51	1.17	.55	2.80	50.55	7.97	27.30
2583	Donerall, 1 mile south.	10-24 inches	3.43	4.38	1.22	2.57	3.03	3.00	5.77	38.59	8.75	27.61

Burley tobacco land—Lower Silurian (Trenton and Hudson River Limestone)—Cont'd.

KENTUCKY AND OHIO DISTRICTS—Continued.

No. sample.	Locality.	Description and depth.	Moisture in air-dry sample.		Organic matter.	Gravel (2-1mm.).		Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
	Kentucky—Cont'd.		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
1927	Lexington, 8½ miles northeast.	Subsoil	2.55	4.51	.14	1.82	2.38	1.54	5.73	45.90	7.88	27.73		
3077	Chatham	12-30 inches	2.54	2.99	.13	.89	1.26	1.35	6.10	47.89	10.36	27.77		
2588	Lexington, 10 miles southeast.	12-24 inches	2.65	3.30	1.23	2.49	2.20	.97	5.28	43.31	10.18	28.45		
2959	Mays Lick, 2 miles south.	do	4.55	2.78	.31	.98	1.10	1.03	11.22	43.46	6.14	28.53		
1849	Winchester	6-18 inches	2.92	5.62	.73	1.43	1.41	1.22	2.23	38.53	16.31	30.20		
2960	Mays Lick, 2 miles south.	24-36 inches	3.79	3.30	.33	.96	1.22	1.25	7.99	46.59	4.72	30.70		
3070	Maysville, 4 miles west.	0-9 inches	5.66	7.40	.11	.19	.34	.61	13.01	31.41	10.19	31.25		
2580	Donerail, one-fourth mile south.	12-24 inches	3.64	4.88	.70	2.54	2.60	1.83	4.31	36.97	7.69	34.36		
287	Lexington, 6½ miles north.	7-24 inches	4.68	4.92	1.12	1.82	1.37	.89	4.34	34.40	10.58	35.24		
2589	Lexington, 10 miles southeast.	24-36 inches	3.52	4.10	.93	2.35	2.07	1.12	4.92	36.03	8.11	35.53		
3069	Germantown, one-half mile east.	12-30 inches	3.61	3.91	.27	.58	.94	1.16	4.75	38.60	9.27	38.37		
2586	Lexington, 10 miles southeast.	24-36 inches	3.89	4.38	1.43	2.80	2.35	1.40	4.10	33.34	8.05	38.62		
2957	Maysville, 9 miles south.	12-30 inches	5.51	4.22	.46	.80	.89	1.20	9.06	34.55	6.42	38.63		
1702	Lexington	9-18 inches	.76	8.53	.00	.00	.24	.11	.97	38.70	11.20	38.92		
3071	Maysville, 4 miles west.	do	4.76	4.82	.13	.20	.23	.44	10.44	30.12	7.98	40.17		
2581	Donerail, one-fourth mile south.	24-36 inches	4.26	4.86	3.01	3.21	5.24	3.42	5.03	26.42	5.94	40.88		
3071	Maysville, 4 miles west.	9-18 inches	3.23	5.02	.05	.13	.25	.53	10.21	29.22	9.94	42.70		
3080	Augusta, 1 mile south.	0-12 inches	5.80	5.10	.05	.13	.25	.46	7.67	28.75	9.10	43.20		
	Average		3.48	4.42	.64	1.63	1.44	1.22	7.04	39.77	9.36	31.62		

Erport tobacco land.

KENTUCKY AND TENNESSEE DISTRICTS.

2611	Clarksville, Tenn., 9 miles southeast.	Subcarboniferous limestone, 9-18 inches.	1.32	2.83	0.62	0.87	1.15	1.62	6.65	66.68	6.42	12.14										
2605	Clarksville, Tenn., 11 miles east.	Subcarboniferous limestone, 6-24 inches.	1.24	2.74	2.47	4.63	6.37	7.71	10.37	45.29	4.69	14.52										
2606	do	Subcarboniferous limestone, 24-36 inches.	1.20	2.36	4.58	7.99	9.04	10.20	9.90	34.74	4.96	15.24										
2612	Clarksville, Tenn., 9 miles southeast.	Subcarboniferous limestone, 18-27 inches.	1.33	3.57	.28	.64	.93	1.67	5.17	60.45	9.38	15.24										
3158	Hopkinsville, Ky., 2 miles south.	Subcarboniferous limestone, 0-12 inches.	2.26	2.96	.00	.05	.15	1.06	9.94	63.14	5.56	15.75										
3232	Henderson, Ky., 9 miles south.	Subcarboniferous limestone, 9-36 inches.	2.30	1.80	.34	.34	.30	.66	13.83	60.20	4.09	16.48										
1105	Earlington, Ky.	Carboniferous sandstone, 16-18 inches.	1.78	2.91	.18	.65	.94	1.74	19.83	47.72	6.14	17.03										
2619	Clarksville, Tenn., 6 miles east.	Subcarboniferous limestone, 9-18 inches.	1.28	3.06	.07	.14	.52	1.76	4.11	64.43	6.78	18.25										
2638	Springfield, Tenn., 1½ miles north.	Subcarboniferous limestone, 9-18 inches.	1.17	2.35	.28	.36	.45	1.69	10.97	56.22	7.16	18.97										

Export tobacco land—Continued.

KENTUCKY AND TENNESSEE DISTRICTS—Continued.

Number.	Locality.	Description and depth.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.005 mm.).	Fine silt (0.01-0.0005 mm.).	Clay (0.005-0.0001 mm.).
3135	Woodburn, Ky., 1 mile north.	Subcarboniferous limestone, 0-12 inches.	P. ct. 2.38	Pc. t. 2.42	P. ct. .02	P. ct. .13	P. ct. .23	P. ct. 3.72	P. ct. 15.35	P. ct. 52.52	P. ct. 5.91	P. ct. 19.05
2923	Springfield, Tenn., 4 miles north.	Subcarboniferous limestone, 9-18 inches.	1.63	4.10	.00	.11	.15	.59	3.54	58.44	12.30	19.21
1720	Clarksville, Tenn., 5 miles northeast.	Subcarboniferous limestone, 6-30 inches.	.78	4.14	.00	.04	.13	.91	8.46	56.46	8.98	19.38
726	Adams Sta., Tenn.	Subcarboniferous limestone, subsoil	1.63	3.08	.00	.05	.15	.74	2.04	61.85	10.45	20.20
3215	Farmington, Ky., 2½ miles northwest.	Lafayette or Columbia, 9-27 inches.	2.66	2.40	.00	.06	.16	.34	12.10	57.95	4.10	20.50
1099	Newstead, Ky.....	Subcarboniferous limestone, 6-18 inches.	2.10	3.06	.05	.18	.11	.34	5.13	63.28	5.19	20.55
1880	Clarksville, Tenn., 8 miles northeast.	Subcarboniferous limestone, 0-6 inches.	.84	4.82	.00	.00	.32	1.29	10.77	46.66	15.12	20.63
2645	Springfield, Tenn., 1¼ miles north.	Subcarboniferous limestone, 9-18 inches.	1.53	2.31	.15	.59	.50	.96	9.33	55.27	7.79	20.92
2598	Clarksville, Tenn., 8 miles east.	Subcarboniferous limestone, 12-24 inches.	1.52	3.44	.14	.23	.40	1.40	7.21	57.29	6.87	21.18
2615	Clarksville, Tenn., 6 miles east.	Subcarboniferous limestone, 9-18 inches.	1.35	3.00	.36	.31	.70	2.62	4.00	59.33	7.00	21.20
2646	Springfield, Tenn., 1¼ miles north.	Subcarboniferous limestone, 18-27 inches.	1.82	2.65	.71	.81	.60	1.09	8.86	52.55	8.24	22.15
2647	do	Subcarboniferous limestone, 27-36 inches.	1.81	2.56	1.21	1.20	.88	1.41	10.51	50.46	6.30	22.45
2599	Clarksville, Tenn., 8 miles east.	Subcarboniferous limestone, 24-36 inches.	1.35	2.48	.24	.35	.59	1.47	8.31	55.55	6.24	22.61
2609	Clarksville, Tenn., 9 miles southeast.	do	1.63	2.97	2.77	2.35	2.81	3.21	7.35	46.69	5.33	22.68
1719	Clarksville, Tenn., 6 miles east.	Subsoil	.94	4.92	.00	.25	.50	1.65	8.27	53.09	6.99	22.70
2620	do	Subcarboniferous limestone, 18-27 inches.	1.61	3.08	.51	.54	.43	1.53	7.76	56.91	5.67	22.77
2591	Clarksville, Tenn., 7 miles east.	Subcarboniferous limestone, 8-24 inches.	1.41	2.55	.01	.01	.08	.39	3.03	62.02	6.27	22.82
3225	Corydon, Ky., three-fourths mile southeast.	Carboniferous sandstone, 9-36 inches.	2.81	3.34	.00	.00	.02	.06	18.35	48.60	4.29	23.17
1379	Allen Springs, Ky..	Subcarboniferous limestone, subsoil.	1.67	3.31	.20	.46	.63	2.23	13.65	47.09	6.58	23.26
2592	Clarksville, Tenn., 7 miles east.	Subcarboniferous limestone, 24-36 inches.	1.49	2.39	.00	.01	.05	.26	3.81	60.97	6.76	23.31
1431	Bowling Green, Ky.	Subcarboniferous limestone, 6-18 inches.	1.75	2.99	.11	.25	.50	2.34	13.51	47.52	7.20	23.43
3217	Farmington, Ky., 2 miles west.	Lafayette or Columbia, 9-24 inches.	4.08	2.46	.00	.02	.14	.46	14.09	50.50	4.56	23.60
2630	Springfield, Tenn., 4½ miles north.	Subcarboniferous limestone, 18-27 inches.	1.72	4.27	.93	.47	.44	1.06	11.43	48.38	6.70	23.88
2633	Springfield, Tenn., 7 miles north.	Subcarboniferous limestone, 9-18 inches.	2.56	3.75	.30	.41	.38	.66	10.72	48.50	7.91	24.34
2608	Clarksville, Tenn., 9 miles southeast.	Subcarboniferous limestone, 6-24 inches.	1.59	3.08	1.10	1.34	1.42	2.17	7.00	51.26	6.42	24.43
3136	Woodburn, Ky., 1 mile north.	Subcarboniferous limestone, 12-24 inches.	4.02	1.80	.13	.35	.36	3.72	11.85	48.50	4.96	24.90

Export tobacco land—Continued.

KENTUCKY AND TENNESSEE DISTRICTS—Continued.

No sample.	Locality.	Description and depth.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1 mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
3171	Hopkinsville, Ky., 9½ miles south.	Subcarboniferous limestone, 12-36 inches.	3.63	2.43	.01	.12	.16	.44	7.71	55.44	5.16	25.00
3197	Paducah, Ky., 15 miles south.	Lafayette or Columbia, 9-30 inches.	4.60	1.88	.00	.02	.08	.22	10.95	51.91	4.08	25.35
2601	Clarksville, Tenn., 11 miles east.	Subcarboniferous limestone, 9-18 inches.	1.60	2.68	.03	.09	.21	.85	5.93	55.45	6.46	25.67
2624	Springfield, Tenn., 4 miles north.	Subcarboniferous limestone, 18-27 inches.	1.70	3.18	.01	.07	.13	.52	4.51	53.77	9.41	26.06
2629	Springfield, Tenn., 4½ miles north.	Subcarboniferous limestone, 9-18 inches.	2.06	4.18	1.99	.81	.50	.98	7.87	47.10	6.75	26.12
3169	Hopkinsville, Ky., 5 miles south.	Subcarboniferous limestone, 12-36 inches.	3.88	2.88	.10	.41	.57	2.08	10.84	47.19	5.80	26.33
2602	Clarksville, Tenn., 11 miles east.	Subcarboniferous limestone, 18-27 inches.	2.33	2.64	.02	.14	.32	.00	5.91	55.08	5.89	26.85
3137	Woodburn, Ky., 1 mile north.	Subcarboniferous limestone, 24-36 inches.	3.34	2.48	.15	.35	.51	6.46	15.14	40.46	4.40	27.00
2636	Springfield, Tenn., 7 miles north.	Subcarboniferous limestone, 6-18 inches.	1.81	3.54	.88	.90	.99	2.49	13.64	41.91	5.76	27.03
3227	Corydon, Ky.....	Carboniferous sandstone, 9-24 inches.	3.64	2.60	.00	.00	.02	.07	12.37	52.46	3.02	27.05
3159	Hopkinsville, Ky., 2 miles south.	Subcarboniferous limestone, 12-36 inches.	4.56	2.80	.03	.10	.21	.91	8.72	52.10	4.42	27.15
3138	Woodburn, Ky., 1 mile north.	Subcarboniferous limestone, 36-72 inches.	2.72	3.10	.11	.16	.92	17.48	18.37	28.07	3.51	27.53
3209	Fancy Farm, Ky., 3½ miles north.	Lafayette or Columbia, 9-27 inches.	4.82	3.06	.03	.03	.06	.11	12.32	48.63	4.65	28.23
3128	Planol, Ky.....	Subcarboniferous limestone, 12-36 inches.	3.74	3.18	.08	.53	.44	.92	8.33	49.99	5.77	28.55
3134	Rich Pond, Ky., 1½ miles north.	do	4.48	3.21	.00	.11	.33	.67	8.36	47.74	4.86	30.38
2642	Springfield, Tenn...	Subcarboniferous limestone, 12-24 inches.	2.87	3.11	.00	.03	.04	.19	3.79	50.91	7.43	31.55
2594	Clarksville, Tenn., 5 miles east.	Subcarboniferous limestone, 9-18 inches.	2.48	3.16	.35	.22	.30	.86	6.23	48.08	5.32	31.77
3139	Woodburn, Ky., 1 mile north.	Subcarboniferous limestone, 72-96 inches.	3.86	3.42	.17	.87	.82	3.94	8.63	38.62	4.68	36.30
	Average.....		2.28	3.01	.41	.59	.74	1.97	9.37	52.10	6.36	22.88



UNIVERSITY OF MICHIGAN



3 9015 06964 4394

